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An Energy and Fuel Demand Model for the Ohio River Basin Energy Study Region

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Washington, DC

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AN ENERGY AND FUEL DEMAND MODEL FOR THE OHIO RIVER BASIN ENERGY STUDY REGION

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16. ABSTRACT

This report was prepared in support of the Ohio River Basin Energy Study (ORBES), a multi-disciplinary program supported by the U.S. Environmental Protection Agency. An energy and fuel demand model was developed for the ORBES study region, which includes all of Kentucky, most of West Virginia, substantial portions of Illinois, Indiana and Ohio, and southwestern Pennsylvania. This input-output model had to be at the sub-state level. Given parameters specified by other ORBES researchers, the model projects economic activity as well as fuel use by end-use sector for future time periods in the study region. Alternative specifications of the various parameters define the scenarios of interest.

Chapter 1 discusses the construction of the energy and fuel demand model. Chapter 2 provides information on implementation of parameter values that define the scenarios. Scenario runs are analyzed, compared, and general conclusions drawn in Chapter 3.

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FOREWORD

The Ohio River Basin Energy Study (ORBES) is an interdisciplinary, multiuniversity inquiry into the environmental, economic and social impacts of energy facility development in a major portion of the Ohio River Basin. The study was initiated by the U.S. Environmental Protection Agency in 1976 in response to a directive from the U.S. Senate Appropriations Committee.

Most of the ORBES research was conducted by a group of faculty members at the University of Illinois, Indiana University, the University of Kentucky, the University of Louisville, The Ohio State University, the University of Pittsburgh, Purdue University and West Virginia University. In a few instances, the necessary expertise was found at other universities or independent research organizations.

This report is one of a series produced in support of the overall ORBES assessment. For a summary of the entire study, see Ohio River Basin Energy Study (ORBES): Main Report, by the ORBES core team. The main report (EPA-600/7-81-008) has been published by the Environmental Protection Agency.

ACKNOWLEDGEMENTS

This is a report of work completed on developing an input-output model of energy and fuel use for the Ohio River Basin Energy Study project. The work has been funded under grant number EPA R805585 and subcontract under prime contract EPA R805588 through the U.S. Environmental Protection Agency. In addition to the authors listed on the title page, Mike Rieber, then of the Center for Advanced Computation, University of Illinois, was responsible for initiating the project some two-and-one-half years ago and was the principal investigator on the initial subcontract which provided funding for model development work.

Special thanks are also extended to Marilyn Rose for her very competent typing services and assistance in preparing the final version of this report.

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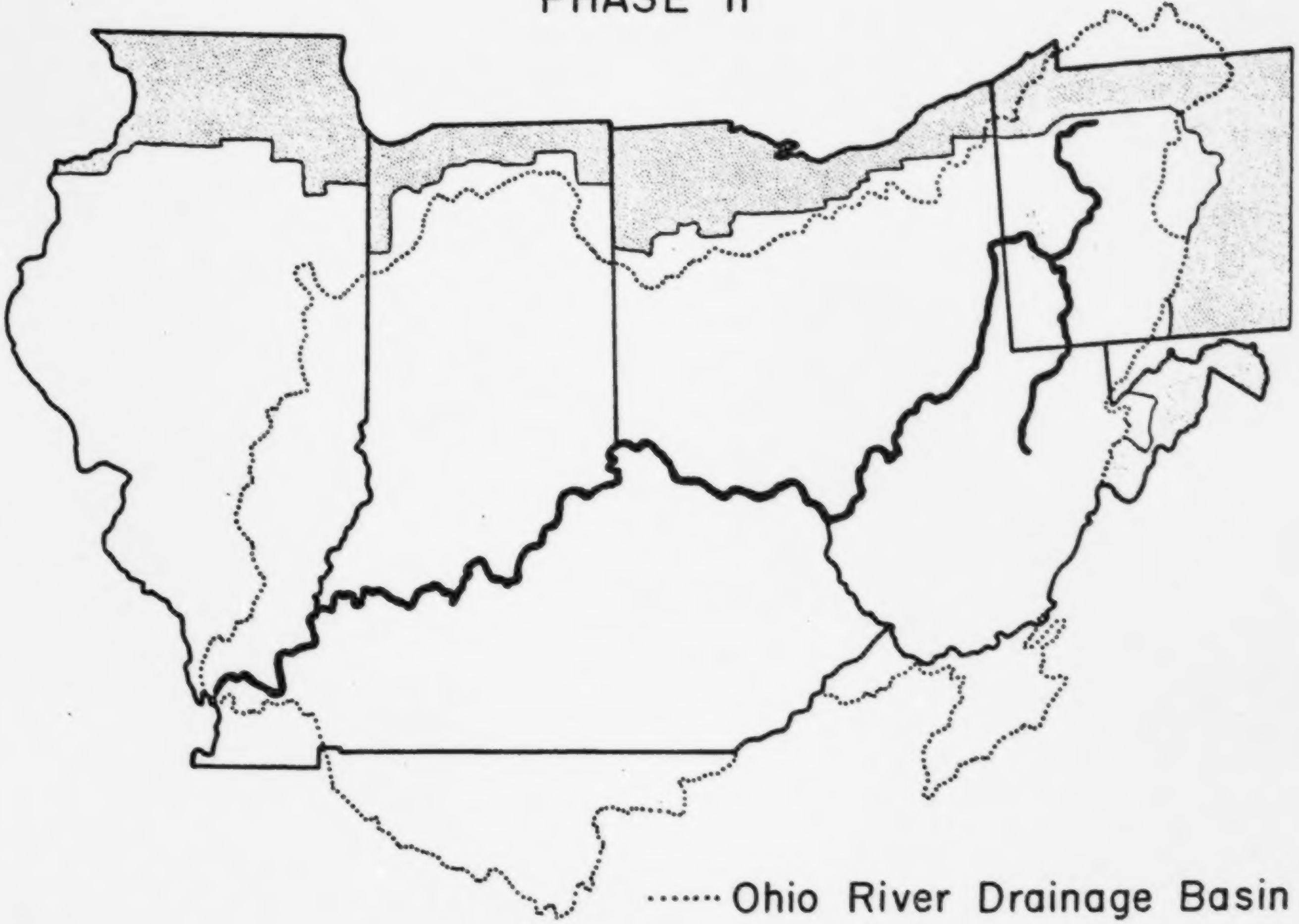
PREFACE

The Ohio River Basin Energy Study (ORBES) is charged with assessing "...the potential environmental, social, and economic impacts of the proposed concentration of power plants in the lower Ohio River Basin." Phase II of the project focuses on a regional analysis consistent with the above mandate. The study boundaries for ORBES Phase II include all of Kentucky and portions of Illinois, Indiana, Ohio, Pennsylvania, and West Virginia (see Figure 1). The regional boundaries were determined in such a way as to include desired portions of the Ohio River drainage basin as well as regional coal fields.

For ORBES Phase II, alternative regional characteristics for future years are obtained through scenario and impact models. The input-output model of economic activity and energy and fuel use falls into the scenario model classification. For the ORBES project, it was necessary to develop an input-output model at the substate level, other than the case of Kentucky where the entire state lies within the ORBES boundaries. Given parameters specified by other ORBES researchers or the ORBES Core Team, the input-output model provides projections of economic activity as well as fuel and energy use by end use sector for future time periods in the ORBES region. Alternative specifications of the various parameters define the scenarios of interest to the ORBES Core Team.

Chapter 1 discusses the construction of the energy and fuel demand model. Chapter 2 provides information on implementation of parameter values which define the scenarios of interest to the Core Team. Scenario runs are analyzed, compared, and general conclusions are drawn in Chapter 3.

FIGURE I
OHIO RIVER BASIN ENERGY STUDY REGION
PHASE II


······Ohio River Drainage Basin

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1. The ORBES Energy and Fuel Demand Model

1.1 The Input-Output Model

Input-Output analysis provides an efficient and detailed accounting scheme for tracing transactions between firms in a consistent manner (see, for instance, 1). Consumption is divided into two classes, intermediate and final; the former characterizing transactions between firms and the latter involving consumption by the components of final demand: consumers, governments, export markets, and investment. When modeling an economic system, there always exists a problem of assigning firms to particular industry groups. In this work, classification is according to the Standard Industrial Classification (SIC) scheme. The SIC system aggregates groups according to specified criteria: for example, SIC 20 (Food and Kindred Products) contains all firms producing dairy and meat products while SIC 201 contains only firms producing meat products and SIC 2011 contains firms which are meat packing plants. The degree of specificity rises as one moves to larger digit numbers in the SIC classification.

In an input-output model, flows between industries may be represented by an n by n matrix of interindustry transactions. These flows represent raw materials, semi-finished and finished products. Final consumption is then shown as final demand: m sectors, for instance, include consumers, governments, foreign markets, investment and interregional exports. In a static model, flows between industries are flows on current account only. Goods which are regarded as investment or capital goods are allocated to the investment portion of final demand.

It is a convention in input-output analysis that flows from firms to final demand markets via wholesalers and retailers are shown as direct sales from firms to final demand. The summation of sales from an industry to all other industries and sales to final demand is total output. The vector of total output is equal to the vector of total input and the accounting balance is provided by the elements categorized as primary inputs. Included are the various components of value added (wages and salaties, entrepreneurial income, and undistributed dividends), and interregional and foreign imports.

In the discussion of the ORBES input-output model, it is useful to establish an accounting system of notation.

Let x_{ij} be the flow of goods from industry i to industry j, and let Y_i be the flow of goods from industry i to all final demand sectors and let X_i be the total output (input) of industry i. Then the following accounting balance is true for all i industries:

$$\sum_j x_{ij} + Y_i = X_i \qquad (1.1)$$

Let a_{ij} represent the cents worth of the output of industry i used per dollar of output of industry j. Then:

$$a_{ij} = x_{ij}/X_j$$

and this may be rearranged to read

$$x_{ij} = a_{ij}X_j$$

We may now substitute for x_{ij} in equation (1.1):

$$\sum_j a_{ij}X_j + Y_i = X_i \qquad (1.2)$$

Equation (1.2) will be true for all i industries. It will be more convenient to express the system in matrix form. Let X, Y represent n by 1 vectors of total output (input) and final demand respectively and let A represent an n by n matrix of input coefficients a typical element of which will be a_{ij}. Then:

$$AX + Y = X$$

Rearranging and factoring out the X vector, we have:

$$X - AX = Y$$

$$[I - A]X = Y$$

$$X = [I - A]^{-1}Y \qquad (1.3)$$

The matrix $[I - A]^{-1}$ is known as the Leontief Inverse matrix. It provides a summary of the rounds of spending and respending that take place when an impulse is injected into the economy by one of the components of final demand. In essence, the Leontief Matrix in equation (1.3) is a summary version of the following process:

$$I + A + A^2 + A^3 + A^4 + A^5 \ldots$$

If we let b_{ij} represent an element of the Leontief Inverse Matrix, then the column summations in this matrix provide us with the specific industry multipliers relating a change in one unit of final demand to the direct and indirect changes in output in all other industries. If m_j represents the multiplier of the j th industry, then:

$$m_j = \sum_i b_{ij}$$

In summary, the input-output model is driven by the final demand vector, the latter initiating changes in activity levels in all industries. The level of impact on any one industry from a change in final demand will, of course, vary depending upon the production process involved and the nature of the backward and forward linkages between this industry and all other industries.

It was noted earlier that the input-output model aggregates firm activity into industrial sectors and presents an accounting of transactions between industrial sectors and groups of firms portraying transactions between the firms per se. To accomplish this task, a number of assumptions require elaboration. Flows from firms to wholesalers to retailers to final demand consumers, if shown in an input-output table, would result in a very sparse matrix with most of the entries shown in the wholesale and retail trade sectors. In input-output analysis, flows through the trade sector are shown via the mark-up margins; in other words, a consumer purchasing an automobile in an input-output model would involve two transactions. The first would be the purchase of the automobile from the manufacturer and the second, the purchase of a "mark-up" from the retailer.

Similar conventions apply to other sector purchases which involve the trade account. The margin referred to above includes operating expense and profit to the wholesaler or retailer. All transactions in the system are measured in dollars: this obviates the problem of comparing tons of coal with rolls of finished steel. Two alternatives are available: (1) measurement in producers' prices or (2) measurement in purchasers' prices. In the case of the former, distribution costs are excluded: when these are added to producers' prices, the resulting sum will be purchasers' prices. In the producers' price system, distribution costs are allocated to the trade and transportation sectors. It is assumed that purchasers of a good will also pay a fixes proportion to the trade and transportation sectors to accomplish the purchase of a good from another sector. The 1967 national model adopted for this work shows transactions in producers' prices and, hence, the ORBES model is similarly structured.

The problem of classification of industries at the regional level is not a trivial one. Essentially, two problems are involved in classification. The first is to obtain as much detail as possible to avoid illegitimate aggregations of firms within one sector. The second problem relates to the prior identification of sectors which were heavy users of energy and for which separation was absolutely essential. Even with 484 sectors at the national level, all aggregation problems are not solved, since there will still be sectors producing more than one type of commodity and there will still be cases where the same commodity may be produced by more than one industry. These problems cannot be solved by greater disaggregation. In fact, the early input-output models developed by Stone (1) were really commodity-industry input-output models rather than industry-industry models. The Canadian accounting system follows Stone's idea with the added advantage that one-to-one correspondence between industries and commodities need not be assumed. Hence, rectangular matrices can result by allowing firms to produce more than one commodity.

In the national model, the relationships are strictly industry-industry, with the caveat that, wherever possible, homogeneity of input patterns was sought in assigning firms to sectors. The problem of secondary products was treated in two different ways. The first method transfers the secondary product to the sector in which the product is the major output. In addition, all the various inputs and value added components which were needed to make the secondary product would be transferred to the industry in which the good was the primary product. Hence, the output of each industry would consist almost exclusively of primary products and the input structure would most closely approximate a single product production function. On the other hand, there are many problems involved in assembling an input-output table without the added complication of requesting firms to distinguish input structures for different products. Furthermore, impact analysis would be difficult to accomplish since one could not very easily translate product impacts into industry impacts. The alternative method has come to be known as the "transfer" method: this approach leaves secondary production where it originates, but also adds it to the output of the primary industry. Thus, secondary production is treated as though it were sold to the primary industry and, hence, the distribution pattern would resemble the product of the primary industry. This procedure greatly simplifies the accounting system although it does result in the development of production structures which include a mixture of primary and secondary production. This problem is dealt with in greater detail in Bureau of Economic Analysis publications (2). In the national model, the transfer approach was used for the mining and manufacturing sectors, while the other approach was used in the trade, construction, and service sectors.

Imports were treated in roughly the same fashion as secondary products if they were substitutable for domestic goods and services. The domestic values of these goods and services were added to the output of the U.S. industry producing similar goods and services. This was accomplished by showing the domestic industry as making a purchase from the import row and from trade, transportation, and insurance industries which were responsible for bringing the imported goods and services into the country. For non-competitive goods and services, the amounts were entered directly into the import row of the industry making the purchase.

Earlier we noted that the choice of sectors for the ORBES region model was premised on the need for as much detail as possible and, in particular, for explicit identification of the energy supply sectors. Our choice of sectors was made on the basis of matching the sectoring scheme with the 1967 national model, the energy models produced at the Center for Advanced Computation (see Bullard (3)) and the problems involved in explicit identification of sectors at the substate level. In the final analysis, 48 sectors[1] were identified: these are shown in Table 1.

For the most part, these sectors are identified at the two-digit SIC level. In some cases, for example sector 24 (Blast Furnaces), we were able to

---

[1] The actual number of sectors in the model is 67. Twelve energy product sectors, whose roles are discussed in the second half of this chapter, are also included. Also there are several energy supply categories, such as shale oil, that are not used.

TABLE 1

SIC CLASSIFICATION OF ORBES I-O MODEL

1: 1100 1200
2: 1310 1320
6: 2910 2990
7: 4920 4932
9-12: 4910 4931
25: 01--
26: 1000 1400
27: 15-- 1380
28: 2010
29: 2000 -2010 2100
30: 2200
31: 2300
32: 2400 2500
33: 2600 -2620 -2630 -2650 2700
34: 2620
35: 2630
36: 2650
37: 2810
38: 2800 -2810 -2820
39: 2920
40: 2950
41: 3000 3100
42: 3200
43: 3310
44: 3320 3390
45: 3330
46: 3340 3350 3360
47: 3400
48: 3500
49: 3600
50: 3710
51: 3700 -3710
52: 3800
53: 4740
54: 4100 4600 4700 -4740 4800 4940 4950 4960 4970
55: 4200
56: 4400
57: 4500
58: 5000
59: 52-- 7396
60: 6000 6100 6200 6400 6700
61: 6500 6600
62: 7000 8100 8900 -8920 7800 7900
63: 7200 7600 7300 -7310 -7396
64: 7310
65: 7500
66: 8000 8200
67: 8400 8600 8920

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TABLE 1 (continued)

NOTE: A preceding minus sign indicates exclusion rather than inclusion.

* See the Standard Industrial Classification for detailed description of sectors.

obtain detail at the three-digit level. In the manufacturing sector, with the exception of sectors 13, 22, and 33, we were able to avoid aggregating together more than one two-digit activity. The degree of detail that we have been able to maintain compares favorably with most regional input-output models that have been produced either from survey of non-survey data. With the possible exception of the Philadelphia region model (which contains many hundreds of sectors), most regional models detail anywhere from 30 to 70 sectors.

In arriving at the sectoring scheme, use was made of the 368-sector U.S. model and the 105-sector CAC model. A major constraint was imposed by the absence of data at the substate level to enable a large number of the sectors to be retained in an unaggregated form. We attempted to retain, wherever possible, as much detail in those sectors whose input pattern was shown to be energy sensitive. These sectors were identified by a criterion which was similar to that developed by Bullard and Sebald (4). Because energy is embodied in all goods in the economy in a very diffuse manner, an element-by-element sensitivity criterion may not yield a satisfactory aggregation scheme. Thus, an alternative criterion is derived which incorporates the concept that an industry should be considered important if total energy use is relatively sensitive to a uniform change in an industry's input technical coefficient, even though there is no single input technical coefficient which has a relatively large sensitivity coefficient. The sectoring scheme is discussed in detail in Appendix A. Application of the scheme resulted in a total of 57 industries (aggregated and unaggregated).

If energy output is of primary concern, then no aggregation scheme could be completely satisfactory. In the aggregated 57th order matrix there are absolutely no unimportant sectors.[2] All of the aggregated sectors have a significant sensitivity. The implication of this analysis is clear: direct and indirect energy use is somewhat evenly embodied in the goods produced in the U.S. economy and, as a consequence, very broad conservation measures may be necessary to appreciably reduce energy consumption.

1.2 Construction of the Regional Model

As observed earlier, the ORBES region includes parts of the states of Illinois, Indiana, Ohio, Pennsylvania, and West Virginia, and all of the state of Kentucky. However, the parts of states which were included were aggregations of counties. This spatial consistency enabled the use of a number of published documents in the process of estimation of the ORBES region control totals for the 48 industries. With few exceptions (for example, Standard Metropolitan Statistical Areas), data on dollar outputs for industry are not available at the substate level in the degree of detail necessary for their use in the input-output model. Consequently, a number of assumptions had to be made to provide a consistent set of estimates of dollar outputs. These assumptions required consideration of the proposition that the productivity differences between firms in the same industry at the state level and those in the portion of the state within the ORBES region were not significant. Hence, output within the ORBES region may be approximated using the following employment-based ratio:

---

[2] This number decreased to 43 nonenergy sectors because disaggregate data were unavailable due to nondisclosure rule.

$$X_i^o = X_i^s \cdot E_i^o / E_i^s$$

where X_i and E_i refer to output and employment and where the superscript o refers to the ORBES region area within a state and the superscript s refers to the state. As shown in Table 2, most of the output and employment data may be obtained directly from census volumes at the state level. Employment at the county level was obtained for most sectors from County Business Patterns (the major source of which is the record file provided by state Employment Security records). For a number of sectors where no state level output data were available, employment estimates were made for the ORBES region and these data were then used to apportion national output to the ORBES region. The underlying assumption in all of these adjustment processes was that the mix of firms in the ORBES region mirrored that of the nation in two senses: (1) in terms of the product mix in each sector and (2) in terms of the mix of technologies utilized in the production of the mix of goods in each sector.

The most commonly used technique for modifying national coefficients has been to develop one or more quotients which may then be applied against the individual national matrix of a_{ij}'s. These quotients have been as simple as the location quotient, which seeks to compare the relative importance of an industry in the region with the similar industry at the national level, to more sophisticated techniques, which involve comparison of relative supply and demand in the region with that in the nation. A large number of these techniques have been evaluated in cases where both survey and nonsurvey tables could be compared for one region. The evidence is somewhat inconclusive: a good summary is provided in Morrison and Smith (5).

The technique which has gained the widest recognition and acceptance is the one originally developed by Stone _et al_. (6) for the purpose of updating a base year matrix to some future date when only the marginal vectors are known. In this case, a new matrix is developed from a base matrix through the following manipulation:

$$A_1 = RA_0S \qquad (1.4)$$

where A refers to the matrix of technical coefficients (the subscripts refer to the base (0) and future (1) year), and R and S are two diagonalized matrices which take into account the effects of fabrication and substitution, respectively (see 11). These matrices are estimated iteratively by adjusting the base year matrix in such a way that the row sum AX, where X is total output in the projection year, is exactly equal to the intermediate output (known) in the projection year, and, similarly, the base matrix is further adjusted to ensure that intermediate purchases, $XA^t i$ are equal to those known in the projection year. The advantage of the technique lies in the fact that n^2 coefficients are modified through the use of only 2n pieces of data. However, there remains a major problem--estimating those two-colume vectors, one

TABLE 2

CONTROL TOTAL DATA SOURCES

Sector	Source of Data
1:	Mineral Yearbook 1967
2:	Mineral Yearbook 1967
3:	Census of Manufactures 1967
4:	Prorated from EEI 1967 state output by ratio of plant locations in and out of ORBES region
5:	Prorated from 1967 National table by 1974 CBP employment data
6:	Farm Income Situation: Fis 218 supplement/August 1971 prorated to the county level using 1974 census of Agriculture
7:	Census of Construction Industries 1967
8:	Census of Manufactures 1967
9:	Census of Manufactures 1967
10:	Census of Manufactures 1967
11:	Census of Manufactures 1967
12:	Census of Manufactures 1967
13:	Census of Manufactures 1967
14:	Census of Manufactures 1967
15:	Census of Manufactures 1967
16:	Census of Manufactures 1967
17:	Census of Manufactures 1967
18:	Census of Manufactures 1967
19:	Census of Manufactures 1967
20:	Prorated from County Business Patterns 1974
21:	Prorated from County Business Patterns 1974
22:	Prorated from County Business Patterns 1974
23:	Prorated from County Business Patterns 1974

(continued)

TABLE 2 (continued)

Sector	Source of Data
24:	Prorated from County Business Patterns 1974
25:	Prorated from County Business Patterns 1974
26:	Prorated from County Business Patterns 1974
27:	Prorated from County Business Patterns 1974
28:	Prorated from County Business Patterns 1974
29:	Prorated from County Business Patterns 1974
30:	Prorated from County Business Patterns 1974
31:	Census of Mineral Industries 1967
32:	Census of Manufactures 1967
33:	Census of Manufactures 1967
34:	Census of Manufactures 1967
35:	Census of Manufactures 1967
36:	Census of Manufactures 1967
37:	Census of Manufactures 1967
38:	Census of Manufactures 1967
39:	Census of Manufactures 1967
40:	Census of Manufactures 1967
41:	Census of Manufactures 1967
42:	Census of Manufactures 1967
43:	Census of Manufactures 1967
44:	Census of Manufactures 1967
45:	Census of Manufactures 1967
46:	Census of Manufactures 1967
47:	Prorated from County Business Patterns 1974
48:	Prorated from County Business Patterns 1974

of total intermediate input and the other of total intermediate output. In modifying a national coefficient matrix, the procedure would involve estimating these two vectors for the region in question and then applying the iterative algorithm to the national coefficient matrix to generate the regional coefficient matrix. Thus:

$$R = TAU \tag{1.5}$$

where A is the national coefficient matrix and R is the regional coefficient matrix. T and U are diagonalized matrices, analogous to R and S above: however, their economic interpretation is less clear. In a sense, they represent constraints on the ability of the regional industries to supply all the necessary inputs to produce the level of output required in the region for intermediate demand.

In the final analysis, it was decided to adopt a procedure rather similar to the one used by Moore and Peterson (7) in the development of their Utah input-output model. The procedure also enable the use of the accounting scheme adopted by the U.S. model and the subsequent adjustments to that model performed by the CONAES group (8) in making projections of future technology at the end of the present century. The approach involves the estimation of net final demand for the region given the national coefficient matrix and a vector of total outputs for the region. In notation, the procedure may be summarized as follows:

$$A^* = AD \tag{1.6}$$

where A represents the national technical coefficient matrix and D represents a diagonalized matrix, a typical entry of which, d_{ii}, is equal to

$$d_{ii} = \frac{1}{1 - m_i}$$

where m_i is the aggregate imports from foreign sources by industrial sector i. Hence, matrix A* is a normalized matrix which includes the production requirements of industry, irrespective of their origin. The solution procedure for the ORBES region takes the following form:

$$A^*X + F + M - E = X \tag{1.7}$$

where F represents net final demand, M represents interregional imports, E represents interregional exports, and X represents gross ORBES output. As F could not be calculated from local data, it was approximated as:

$$F = F^n \cdot Y^{ro} / Y^n$$

where Y represents income in the ORBES region (o) and the nation (n). Since M and E, trade on interregional account, could not be observed separately, the vector V = M - E was derived as a residual from the accounting balance performed on equation 1.7 above. All other values, save for V, are known. Hence, some of the entries in this vector will be negative since it represents net interregional trade.

Baseline estimates of the net exports by industry are needed for determining a vector of parameters that are needed in solving the input-output model. When solving the input-output model for levels of regional production, some relationship between consumption and net imports must be made. Ideally, net imports should be determined from aggregate production cost curves in and out of the region and from the cost of transport. The information for such an analysis could not be collected for even a region of our own choosing, let alone the one under study. The only approach available was to assume in the scenario runs a constant proportion between net exports and production, which is equivalent to assuming a constant proportion between net imports and consumption. The general form of the input-output equation that is solved is

$$Ax + f + Cx = x \, , \qquad (1.8)$$

where C is the diagonal matrix whose elements are the ratio of net exports to total regional production in the base period. Thus, when the model is solved using scenario parameters, the term Cx represents net exports.

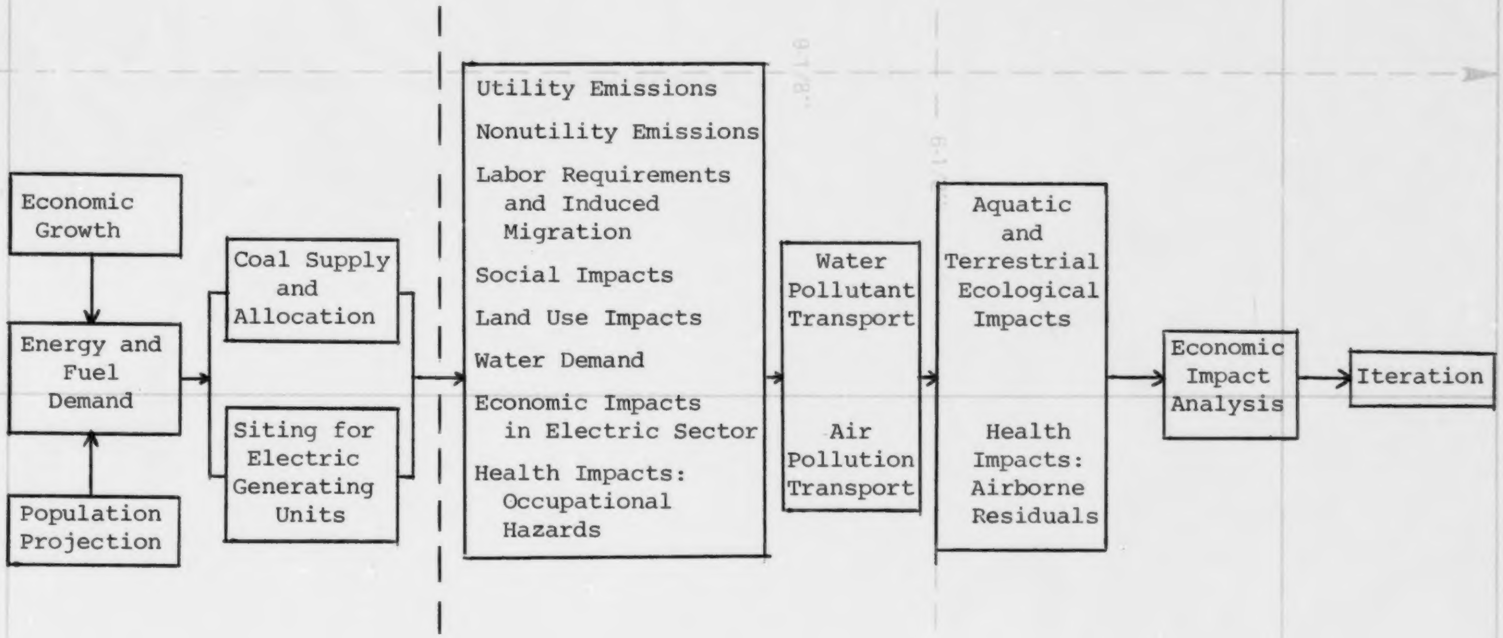
1.3 The Energy Supply-Product Input-Output Model

The second component of the ORBES Phase II fuel and energy use model arises from the need to deal with interfuel substitution in scenario specifications. For that purpose we have used an extension of the classical input-output model called the supply-product input-output model. The extension is accomplished by adding another set of variables and then by partitioning the input-output matrix as shown in Figure 2. All nonenergy sectors are grouped together in one sub-vector. The energy sectors are divided into two components--energy supply and energy products. The energy product sectors represent various categories of energy use, such as air conditioning, space heating, and automotive transport. These are artificial sectors that are assumed to be implicit in any energy consuming activity. It follows that energy product demands are not exported and, thus, the consumption of an energy product demand equals its production. Except for energy transformation, such as converting coal into electricity, all energy demand is satisfied by the energy product classifications. Thus, the energy supply categories have no inputs to the nonenergy sectors. The consumption of an energy supply category equals the amount consumed in energy transformation processes plus the sum of the contribution that the energy supply category makes to the total production of each energy product demand.

The distinguishing feature of the model is that the entries in the submatrices are expressed variously in \$/\$, btu/\$, \$/btu, and btu/btu, rather than in \$/\$ in the regular input-output matrix. The coefficients in the A_{ss}, A_{sp}, and A_{ps} submatrices are expressed in btu/btu: in \$/\$ in the A_{nn} matrix, and in btu/\$ and \$/btu in the A_{pn} and A_{ns} matrices, respectively. As there are no trading relations between energy supply and the nonenergy sectors, A_{sn} has no entries. Similarly, there is no trading among the energy product sectors and between the nonenergy and energy product sectors. Note that the energy supply sectors can and do make purchases from nonenergy sectors.

Figure 2

Scenario and Impact Models: Sequential Steps in ORBES Assessment


Economic Growth
Energy and Fuel Demand
Population Projection
Coal Supply and Allocation
Siting for Electric Generating Units
Utility Emissions
Nonutility Emissions
Labor Requirements and Induced Migration
Social Impacts
Land Use Impacts
Water Demand
Economic Impacts in Electric Sector
Health Impacts: Occupational Hazards
Water Pollutant Transport
Air Pollution Transport
Aquatic and Terrestrial Ecological Impacts
Health Impacts: Airborne Residuals
Economic Impact Analysis
Iteration

Fuel substitution takes place within the A_{ss} and A_{sp} submatrices. In the 63-sector ORBES model, 12 energy supply sectors are identified:

1) coal mining
2) crude petroleum, gas
3) shale oil
4) gasified coal
5) solvent-refined coal
6) refined petroleum products
7) natural gas utilities
8) coal combined cycle electric
9) fossil electric utilities
10) nuclear electric utilities
11) high-temp gas reactor
12) renewable electric utilities

Within the submatrices, many of the entries are zero, since very few physical transfers take place. For example, almost all crude oil will go to a refinery and, from the refinery, the energy form (refined oil) will be distributed to the nonenergy sectors. Within the energy supply/product matrices, substitution can take place in response to changes in the availability of supply, changes in relative prices, and as a result of the introduction of new technology. The process is described by Behling _et al_. (9) as follows:

> "A relative increase in oil and gas fired electric generating plants versus coal fired plants can be depicted by increasing the input coefficients for the fossil fueled electrical column vector in the refined oil and pipeline gas rows and decreasing the coefficients in the coal row. Changes in the energy products coefficients and nonenergy sector coefficients in the fossil electricity column are not required. In like manner, a shift in the way a specific energy product is produced can be depicted by a coefficient change in the A_{sp} sub-matrix. A change in fossil electricity versus refined oil for space heating, for example, changes only the fossil electric and refined oil coefficients within the space heat column vector."

Energy use, therefore, appears as a flow from supply -----> to product -----> to nonenergy sector. Energy consumed by final demand will be shown in the Y_p vector (i.e., consumers purchasing oil for home heating) and not as a direct purchase from the energy supply sectors. The entries in the Y_s vector of final demand represent energy exports, imports, and net inventory changes.

The supply-product model used for the ORBES region embraces both characteristics in that endogenous substitution is made possible but is limited to fuels: _ex ante_ changes are made in technological structure through the modification of many coefficients in the nonenergy sectors. These latter changes were introduced through the work accomplished by the CONAES group (10). The activities of this group, composed of industry experts from a variety of academic, government, and private sector backgrounds, involved the estimation of technological change in production practices by the year 2000. In an analogous fashion to the procedure developed by Miernyk (11), it was assumed that changes would be embodied in the production function of the average firm in the early part of the next century.

The methodology involved the identification of the most likely changes in terms of the foreseen reduction *in toto* of energy inputs and the possibilities of substitution by nonenergy inputs.[3] The estimates of response to likely changes (increases) in energy prices was estimated by industry experts rather than through the familiar economists' price elasticity of demand models. The judgmental approach may be justified on the grounds that the historical data necessary to implement any model of this kind (involving energy-related price changes) are inappropriate when viewed against the energy price changes of the last several years.

In addition to the advantage of being able to analyze the effect of energy substitution, the model is also useful for incorporating energy conservation considerations in a much more direct manner than that allowed by the conventional input-output framework. For example, using the conventional framework, it is difficult to examine the effect of the reduction of space heat requirements due to increased building insulation. Because energy consumption by each industry is not broken down by end uses, the determination of energy input to each industry due to space heat requirement is a difficult task. With the supply-product formulation, the space heat requirements for each industry are parameters of the model. Thus, the change can be effected simply by scaling the technical coefficients in the space heat row by the appropriate scale factor.

Though arbitrary fuel substitution possibilities can be handled by the supply-product input-output model, the elements of the fuel mix sub-matrix, A_{sp}, cannot be arbitrarily set. Each column of A_{sp}, which represents the fuel mix for a particular energy product, must satisfy an energy conversion constraint equation. For instance, for each btu of fuel oil that is burned to produce space heating, approximately .7 btu of space heat is produced. Because the conversion of electricity into heat is essentially lossless, a btu of electricity converts into a btu of space heat. If space heat is only produced by electric resistance heating, then fuel mix column for space heating would consist of a unit vector with the component corresponding to electric generation bring unity, If all space heating was produced from fuel oil, the space heat column would have the fuel oil component being 1/.7, while all other components are zero. Finally, if x and y represent the fractions of space heating supplied by electricity and fuel oil, respectively, then the components for the space heating column of A_{sp} would be x and y/.7 for electricity and fuel oil. Thus, if α is a specific column of the A_{sp} sub-matrix corresponding to a particular energy product and ϕ is the corresponding vector

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[3] It should be pointed out that the term "nonenergy" input does not imply that energy is not utilized in its production: the distinction, in the case of the ORBES model, would be between substitution among the first five sectors as opposed to substitution among the remaining 43 sectors. The latter comprise the nonenergy sectors but, as the matrix shown in Figure 5.1 demonstrates, these sectors do consume energy in the form of energy products (shown as entries in the A_{pn} matrix).

Figure 3

Energy Input-Output Model

	Supply	Product	Non-Energy	Final Demand	Total Output
Supply (Btu)	A_{ss}	A_{sp}	0	Y_s	X_s
Product (Btu)	A_{ps}	0	A_{pn}	Y_p	X_p
Non-Energy ($)	A_{ns}	0	A_{nn}	Y_n	X_n

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of conversion efficiencies,[4] then $\phi'\alpha=1$.

The generation of A_{sp} sub-matrices which meet the above constraint can be done simply by specifying the proportion of demand for a particular energy product, sometimes called the basic energy demand (BED), that is satisfied by each particular energy supply classification. Forming a column vector from the proportions of all supply categories used in the production of a unit of an energy product, and then arranging the column vectors corresponding to all energy product classifications into a matrix, we form what shall be termed the fuel mix matrix. The A_{sp} sub-matrix is formed by dividing the fuel mix matrix by the corresponding energy supply to energy product conversion efficiency. It is easy to see that this A_{sp} sub-matrix will satisfy the energy balance constraints if all of the columns of the fuel mix matrix sums to unity. It was convenient to modify the fuel mix matrix rather than directly modifying the A_{sp} sub-matrix during the process of regionalization of the supply-product input-output model and during the development of determining the scenario specific A_{sp} sub-matrices. In this way, fuel substitutions can be easily specified that do not violate the energy balance constraints.

1.4 Derivation of the Energy Consumption Baseline

Although energy supply consumption by end sector in the supply-product input-output model is not explicitly represented, once A_{sp} has been specified, energy consumption by fuel type by each industry can be determined. Energy supply consumption by industry is determined by transforming the energy product requirements of a particular industry by the A_{sp} sub-matrix. Once this transformation has been performed,[5] the resulting equations which determine the production levels for the energy supply and nonenergy industries can be solved independent of energy product sectors. This set of equations have the same form as the classical input-output model. Thus, the supply-product input-output model can be viewed as a structural model that can be transformed into a reduced form model which, in this case, is the classical input-output formulation.

Given regional estimates of the production of goods and services, fuel consumption by each sector can be determined in the reduced form model. The cells in the resulting fuel consumption table then can be summed and an aggregate total can be determined for the residential, commercial, and industrial sectors. This allows the comparison of the input-output baseline with other sources of baseline data.

Because of the disaggregate nature of the model, no direct fuel consumption data could be collected for the ORBES region. Thus, the energy consumption baseline is indirectly determined from other baseline data. The accuracy of the input-output energy consumption baseline is dependent upon the accuracy of several sources of data and the validity of basic assumptions that are made in regional input-output modelling. One of the most important factors that effect the accuracy of the fuel consumption estimate is the accuracy of ORBES production of goods and services. These estimates were compiled by the ORBES energy demand model research project. Another important factor is the estimate of energy product requirements per unit output of goods and services. These estimates would have been very difficult, if not impossible, to collect at the regional level and, thus, national estimates were used. More precisely, we assumed that the national A_{pn} coefficients are applicable to the ORBES region. The compilation of these coefficients are found in Knecht and Bullard (12). The use of national energy product requirements is a reasonable assumption. This amounts to assuming that the amount of energy products required in the production of a good is independent of region. We are still able to specify the aggregate fuel mix of each energy product at the regional level.

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[4] These efficiencies are dimensioned btu of energy supply per btu energy product.

[5] Also the demand for energy products by the final demand sector is transformed into a demand for energy supplies by the same procedure.

Given good estimates of regional production of goods and services, and if the assumpeion that national energy product requirement estimates apply to the ORBES region is reasonable, then it would be possible to tune the implicit energy consumption baseline generated by the input-output model by only modifying the fuel mix matrix. The discrepancies in fuel consumption by industry was assumed to be due to errors in the specification of the fuel mix for process heat. Because space heating is the most significant component of fuel use by the residential and commercial sectors,[6] the fuel mix for space heat was modified to bring the usage of fuels by the commercial and residencial sectors into conformance with Page's estimates (13). After these adjustments were made to the fuel mix matrix, the input-output model projected a lower electricity consumption demand than that estimated by Page. Because no other data sources were available to clear up the discrepancy, miscellaneous electric inputs to all sectors were uniformly increased. Since the input-output baseline was for the year 1967, and Page's energy consumption baseline was for 1974, the comparison of the energy consumption baselines involved prorating the 1967 production by Page's estimates in the increase in gross regional product. Thus, additional errors are introduced due to the balanced growth assumption which is implicit when one prorates estimates. Thus, the discrepancy in the estimates of electricity consumption may be due to unbalanced growth that occurred between 1967 and 1974. Also, the substitution of electricity due to technological change may be an important explanation of why this discrepancy occurred. Unfortunately, no data were readily available which could pinpoint where the discrepancy arose.

1.5 Two Versions of the Model Used in the Scenario Runs

There are two versions of the model which were used in this study. In the version which was first developed, the form was very similar to the classical input-output model formulation, though some of the industries were assumed to have a fixed output level in some or all of the scenarios.[7] The equations were rewritten so that net exports of these sectors were determined rather than the production levels. Most runs of this version of the model required two solutions. After the first run of total demand, electric generation was determined. Then, the fuel mix for electric inputs to energy products were reallocated so that the amount of nuclear and hydro-electric generation would be at the specified levels in the second solution.[8] Another version of the model was specifically designed to allow a simpler solution procedure when the production levels of electric generation and alternative energy technologies are specified. In this formulation, Von Neumann[9] process activity vectors (14) were defined for nuclear and hydro-electric power, coal-steam electric plants which cogenerate waste heat, total energy systems, wind and photo-electric electricity generation which can be centralized or decentralized. Some of these process, such as total energy systems,[10] have multiple outputs. The energy demand equations are explicitly written to determine the amount of conventional fuels necessary to meet energy product demands that are not satisfied by the alternative technology fuels. Also, the model determines the level of fossil fuel electric production when nuclear and hydro-electric production is given. This is done by defining a new variable called central station electric generation. An equation in this model specifies that total central station electric production equals total electric consumption plus line losses and net exports. Finally, the amount of fossil electric generation is determined by an equation which states that fossil electric generation is equal to total central station electric demand minus the prespecified levels of generation from the other central station technologies. Any decentralized production of electricity is assumed to satisfy miscellaneous electric demand with no transmission lines. Because the central station electric classification is the only electric generation variable that appears in the fuel mixes for energy products, no modification of A_{sp} is necessary, and the model does not require iteration to find the solution.

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[6] Though air-conditioning is a major source of energy consumption in the residential and commercial sectors, it poses little problem in terms of determining fuel mixes, since the vast proportion is produced from electricity.

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[7] Nuclear and hydro-electric power production were set in all scenarios. Crude oil and well-head gas production were specified in scenario 5.

[8] Given a reasonable first guess for the electric fuel mix, only one iteration was required to have a small residual between the solution and the specified levels.

[9] The Von Neumann model is the theoretical precursor of all economic activity analysis models. This model is also noteworthy for it was one of the first mathematically formulated economic growth models. In the ORBES energy demand model we have incorporated the concepts of the general Von Neumann process. In this context a process can be loosely defined as a linear transformation of inputs (goods, labor, and depreciated capital) into one or more outputs. The columns in the technical coefficient matrix are special Von Neumann processes with but one output.

[10] It is assumed that the total energy systems consume refined petroleum or natural gas to produce electricity and cogenerated heat which may be used for process or space heating.

2. Scenario Assumptions

2.1 General Discussion

The ORBES Core Team specified a number of scenarios to be run through the energy and fuel demand model. Of interest here is the way these scenarios are given a quantitative dimension which permits analysis using the demand model. It is necessary, for instance, to specify how much conservation can be expected in the region by 1985 and 2000 and in what specific energy uses conservation will occur.

Before discussing these matters, the meaning of enduse efficiency should be clarified. An energy efficiency increase in the industrial and commercial sector is defined as a reduction in the amount of energy product used per unit of output produced. An enduse efficiency increase in space or water heat in the residential sector is defined to be the reduction of energy consumed in these activities on a per-capita basis. In the solution of the model, it is irrelevant whether it is in part achieved by increased insulation, better heat transfer, or by reduction of basic energy demand by, for instance, decreasing thermostat settings.[11]

Table 3 lists the scenario assumptions that are incorporated in the runs of the demand model. Most of the data in Table 3 have been taken directly from the code that implements the scenario runs and many of the parameter changes found in Table 3 can be extracted from the scenario solution tables. Items in the table are organized so that efficiency assumptions are listed first. Items concerning growth rates and fuel mix assumptions for each particular energy use then follow. Finally, miscellaneous assumptions are listed.

Except for scenario 5, the scenario population growth assumptions are uniform across scenarios. Milke's estimate for ORBES region population under the assumption of higher in-migration is 26 million in the year 2000 (15) (the 1970 census figure was 23.06 million). This corresponds to an average per annum growth rate of 0.476 percent. We have assumed that the growth rate up to 1985 is 0.52 percent per annum (the average growth rate from 1960 to 1970 was 0.57 percent per annum).

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[11] This is not to say that the above considerations should not be quantified, for by determining the aggregate enduse efficiency increase in terms of contributions from the above factors will result in a more valid assumption. The inability to precisely specify the factors which determine the aggregate enduse efficiency increases are one of the most disturbing shortfalls of this research effort.

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TABLE 3
Scenario Assumptions Used in the ORBES Energy Demand Model

	Scenario 1	Scenario 2	Scenario 2a	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Environmental Controls	strict	lax	lax	lax	lax	lax	lax
Enduse efficiency assumptions in 2000.	Process heat: 10% increase, water heat 5%, space heat 15%, air cond.: 10%.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Process heat: 5% increase, space heat 7% increase, air cond.: 5% increase.	Same as in Scenario 1.	Process heat: 35% increase, water heat: 20% increase, space heat: 45% increase, air conditioning: 40% increase.
Enduse efficiency assumptions in 1985.	Process heat: 5% increase, water heat 2%, space heat 5%, air cond.: 3%.	Same as in Scenario 1.	N/A	N/A	Process heat: 2% increase, space heat 3% increase, air cond.: 2% increase.	N/A	N/A
Transportation efficiency increases in 2000.	17% decrease for water, air, truck, and rail transport, auto fuel eff. 28 mpg, (modelled after 2000 NEP.)	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	9% decrease for water, air, truck, and rail transport, auto fuel eff. 21 mpg,	Same as in Scenario 1.	No decrease for water, 55% decrease for air, 40% truck, 9% rail. 37 mpg autos, (modelled after CONAES scenario 3.)
Transportation efficiency increases in 1985.	9% decrease for water, air, truck, and rail transport, auto fuel eff. 20 mpg.	Same as in Scenario 1.	N/A	N/A	5% decrease for water, air, truck, and rail transport, auto fuel eff. 17 mpg,	N/A	N/A
Growth in per capita personal motive power demand.	Average of 2.4% per annum.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Average of 2.1% per annum.	No increase over 1974 level.
Growth in the per capita final demand for miscellaneous electric power.	20% increase.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	20% decrease.
Growth in the final demand for nonenergy goods in 2000.	Aggregate grows at an average of 2.47% per annum though different growth rates for individual industries are used. The weights in CONAES scenario 2 are used to determined the growth rates.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1 except CONAES Scenario 1 is used.	Same as in Scenario 1 except the average growth rate is 2.075% per annum.	Same as in Scenario 1 except CONAES Scenario 3 is used.
Conventional technology fuel mix assumptions for process heat in 2000.	55% of process heat basic energy supplied by coal, oil: 10%, gas: 25%, elec.: 10%.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	7% of process heat basic energy supplied by coal, oil: 6%, gas: 85%, elec.: 2%.	Same as in Scenario 1.	40% of process heat basic energy supplied by coal, oil: 22%, gas: 38%, elec.: 0%.

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TABLE 3 (continued)
Scenario Assumptions Used in the ORBES Energy Demand Model

	Scenario 1	Scenario 2	Scenario 2a	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Conventional technology fuel mix assumptions for process heat in 1985.	36% of process heat basic energy supplied by coal, oil: 18%, gas: 37%, elec.: 9%.	Same as in Scenario 1.	N/A	N/A	21% of process heat basic energy supplied by coal, oil: 16%, gas: 56%, elec.: 7%.	N/A	N/A
Conventional technology fuel mix assumptions for water heat in 2000.	Gas: 35%, elec.: 65%.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Gas: 85%, elec.: 15%.	Same as in Scenario 1.	Oil: 13%, gas: 87%.
Conventional technology fuel mix assumptions for water heat in 1985.	Oil: 4%, gas: 57%, and elec.: 39%.	Same as in Scenario 1.	N/A	N/A	Oil: 3%, gas: 79%, and elec.: 18%.	N/A	N/A
Conventional technology fuel mix assumptions for space heat in 2000.	17% of space heat basic energy supplied by oil, gas: 46%, elec. (heat pumps): 37%.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	13% of space heat basic energy supplied by oil, gas: 87%, elec. (heat pumps): 0%.	Same as in Scenario 1.	26% of space heat basic energy supplied by oil, gas: 49%, elec. (heat pumps): 25%.
Conventional technology fuel mix assumptions for space heat in 1985.	1% of space heat basic energy supplied by coal, oil: 29%, gas: 58%, elec. (heat pumps): 10%, elec. (resistance): 2%.	Same as in Scenario 1.	N/A	N/A	3% of space heat basic energy supplied by coal, oil: 34%, gas: 51%, elec. (resistance): 2%.	N/A	N/A
Modifications of nonenergy to nonenergy tech. coef.	Scenario 2 CONAES, (doubling of real energy prices.)	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Scenario 1 CONAES, (real energy prices remain constant.)	Same as in Scenario 1.	Scenario 3 CONAES, (quadrupling of real energy prices.)
Exports of Electricity	Ratio of exports to ORBES production does not change from of 24.6%.	Same as in Scenario 1.	20kMew of additional coal fired capacity in addition to that determined in Scenario 2.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.
Nuclear Power Capacity	No increases over 1986 estimates.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.
Nuclear-elec. power production.	210 trillion btu.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.
Hydro-elec. power production.	35 trillion btu.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.

TABLE 3 (continued)
Scenario Assumptions Used in the ORBES Energy Demand Model

	Scenario 1	Scenario 2	Scenario 2a	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Steel production assumptions in 2000.	Penetration of electric arc process: 28%, 14% less energy input per unit output.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.
Steel production assumptions in 1985.	Penetration of electric arc process: 21%, 4% less energy input per unit output.	Same as in Scenario 1.	N/A	N/A	Same as in Scenario 1.	N/A	N/A
Air conditioning market penetration in 2000.	Increases from 51% in 1974 to 90% in residential sector, while industrial/commercial penetration increases from 65% to 90%.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	Same as in Scenario 1.	No increase over 1974 level.
Air conditioning market penetration in 1985.	Residential: 71%, industrial/commercial: 80%.	Same as in Scenario 1.	N/A	N/A	Same as in Scenario 1.	N/A	No increase over 1974 level.

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Except for scenario 2a in 2000 and scenarios 1 and 2 in 1985, the ratio of electricity exports to production remains at 24.2 percent, the estimated 1974 level. In all scenarios, total production of nuclear power for 1985 is assumed to be 210 trillion btu. For the year 2000 in all scenarios except 2c, no more additional nuclear capacity is assumed to be installed, thus total production by nuclear electric remains at 210 trillion btu. For all scenarios in both 1985 and 2000, total hydro-electric production is assumed to be 35 trillion btu (16). In all scenarios and from all central station electricity production facilities, the assumed transmission loss factor was assumed to be 8.7 percent of total generation.

In the energy demand model, the demand for energy in the production of steel is only affected by aggregate enduse efficiency increases and assumptions concerning the proportions of steel produced by two aggregated processes. One of the two processes is electric arc. All other processes are aggregated into one process loosely termed as blast furnaces. These assumptions do not vary across scenarios. We assume that 28 percent of steel production is by the electric arc process in 2000.[12] The percentage for 1985 is over-optimistically assumed to be 22 percent. The aggregate enduse efficiency increases are assumed to be 4 percent in 1985 and 14 percent in 2000.

For all scenarios except 3 and 6, what could be viewed as optimistic increases in the demand for the basic energy demand for air conditioning. We assumed that the relation of demand for air conditioning is linear with the market penetration of air conditioning. The national market penetration rate for air conditioning was approximately 50 percent in 1974 in the residential sector (18). This percentage is assumed to increase to 71 in 1985 and reach 90 in the year 2000. For the commercial sector, the percentages are 65, 80, and 90 percent, respectively, for the years 1974, 1985, and 2000. With assumed incomes being twice as large, such an increase in market penetration for air conditioning units is quite reasonable. The problem is with the way the assumption is implemented in the model in that with higher energy costs the use patterns of these units will become more discretionary.

Table 3 provides a means for easy comparison of scenario dependent assumptions. As is readily seen, detailed descriptions are only necessary for scenarios 1, 3, and 6. In general, the assumptions of scenarios 2, 2a, 2n, 4, 5, and 5a correspond to those of scenario 1. In particular, scenarios 1 and 2 differ only in environmental controls. Scenario 2a differs from 2 only in that 20,000 MWe of coal-fired and nuclear electric generation capacity are added in the respective scenarios. The conventional technology assumptions for scenario 3 are identical to those of scenario 2. Thus, a difference arises only in that alternative technologies displace some energy demands satisfied by conventional technologies. Scenario 5 is identical to scenario 2, except that the growth for personal automotive transportation and the aggregate growth rate for nonenergy goods by final demand are, respectively, 2.1 and 2.075 percent per annum. In scenario 5a, both growth rates are 3.1 percent.

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[12] This approximately corresponds to Hermelee's assumption in his reference energy system diagram (17).

It is in scenarios 1, 5, and 6 that we find the largest variation in scenario assumptions. An important scenario dependent assumption which differentiates these scenarios is real energy prices. Being the most optimistic scenario, scenario 4 assumes that real energy prices do not change from the present value. In scenario 1, it is assumed that real energy prices double, while scenario 6 assumes that real energy prices quadruple. Thus, in scenario 4, we find the lowest increases in enduse efficiency with energy use reductions on the order of 5 to 7 percent and average vehicle efficiency of 21 miles per gallon. In scenario 1, efficiency increases range from 5 to 15 percent, while average vehicle efficiency is 28 miles per gallon. Scenario 6, as the zero energy growth scenario, assumes enduse efficiency increases on the order of 35 to 45 percent, with personal vehicle efficiencies averaging 37 miles per gallon.

2.2 The Incorporation of Scenario Parameters in the Energy Demand Model

The modification of the baseline data by the scenario dependent data and the subsequent solution of the model is a straightforward process. The modification of the baseline data to incorporate the scenario assumptions involve:

1. Generation of the fuel mix technical coefficient sub-matrices. Also many of the enduse efficiency assumptions are incorporated at this stage.

2. Modification of nonenergy to nonenergy technical coefficients. These changes represented technical innovation assumptions and energy price sensitivity assumptions incorporated in the scenarios of the CONAES study.

3. The specification of the residential demand for energy is made by changing the corresponding elements of the final demand subvector for energy products. Also the demand for personal automotive transportation is specified at this stage.

4. Modification of the final demand for nonenergy goods was done by prorating the corresponding final demand sub-vector by the transformed CONAES weights[13] and then all of the elements uniformly adjusted so that the aggregate growth rate corresponds to the rate specified for each scenario.

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[13] The CONAES study integration model (19) used a different sectoring scheme than that used in the ORBES Energy Demand Model. The procedure required for a transformation can be mechanized since both models can be expressed as aggregations of the 1967 national benchmark IO table. A program was developed to use the best available national data to resolve sectoring clashes whenever they occurred. Because the resolution of sectoring clashes required base comparison vectors of order 357, regional data could not be used in this program.

Once the vector and matrices that have been mentioned above have been modified, the actual system of equations to be solved is pieced together and then solved by decomposition. As described earlier, net exports are determined by the model by assuming that the ratio of net exports to total output for each industry remains the same as the 1974 baseline ratio. The model explicitly solves for total ORBES production by industry. Once total production is known, net exports and total ORBES consumption by industry can be determined. Once consumption by industry has been determined, the solution is then aggregated into what has been called the energy enduse tables. These have been calculated for the purpose of comparison among scenarios. In general, it is difficult to relate changes in the enduse tables to changes in scenario assumptions. But, in most cases, it is fairly easy to perform hand calculations to check the effect of a change in a scenario assumption given the solution to the input-output model.[14]

2.3 Scenario Growth Assumptions

In the growth for the final demand for goods, a general assumption has been made that the growth in the demand for nonenergy goods would loosely be tied to increases in gross regional product, while the growth in the demand for energy products was in general tied to the growth in population. Table 4 contains the computed average growth rates in the final demand for nonenergy goods for scenarios 1, 4, 5, 5a, and 6 in the year 2000.[15] It is readily seen that there is an explicit assumption across all scenarios that people spend an increasing share of their income increase in the purchase of services. Also, as one would expect, the lowest growth rates are associated with the purchase of meats and other food products. Across the various scenarios, the most visible difference is that air transportation grows twice as fast in scenario 4 as in scenarios 1 and 6. As it would be expected, the growth rates in scenario 5 are smaller than those found in the other scenarios, usually by 0.3 to 0.4 percent per annum.

The residential demand for energy products is specified on a per capita basis. Per capita miscellaneous electric use is assumed to increase by 20 percent in all scenarios except scenario 6, in which a 20 percent decrease is assumed. This is motivated by the increased use of electric and electronic appliances which may occur in all but the most pessimistic scenario assumption concerning energy prices. Historically in the U.S., the number of vehicle

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[14] The important computations needed are the solution vectors, the transactions matrix, and (for convenience) the technical coefficient matrix. These vectors and the sub-matrices corresponding to the fuel-mix coefficients have been printed for each scenario.

[15] Scenarios 2, 2a, and 3 growth rates for the final demand for nonenergy goods are assumed to be the same as in scenario 1.

TABLE 4
Average Growth Rates for the Final Demand Nonenergy Goods in Scenarios 2, 6, 4, 5, and 5a

	s2	s6	s4	s5	s5a
25 agriculture	1.71	1.71	1.70	1.44	2.14
26 mining	2.52	2.53	2.51	2.12	3.16
27 construction	2.52	2.53	2.51	2.12	3.16
28 meat products	1.38	1.39	1.37	1.17	1.73
29 food exc. meat products	1.51	1.51	1.50	1.27	1.89
30 apparel and misc text. prod	2.39	2.39	2.37	2.01	2.99
31 misc fabricated text. prod	2.33	2.33	2.31	1.96	2.92
32 logging and misc. wood prod	2.43	2.44	2.42	2.05	3.05
33 misc paper prod and publ.	2.36	2.36	2.34	1.98	2.95
34 paper mills	2.36	2.36	2.34	1.98	2.95
35 paperboard mills	2.36	2.36	2.34	1.98	2.95
36 paperboard containers	2.36	2.36	2.34	1.98	2.95
37 industrial org-inorg chem.	2.39	2.40	2.38	2.01	3.00
38 ag and misc chem.	2.39	2.40	2.38	2.01	3.00
39 plastic and synthetic resins	2.39	2.40	2.38	2.01	3.00
40 paving and asphalt	2.39	2.40	2.38	2.01	3.00
41 rubber and misc plastic prod	2.36	2.36	2.34	1.98	2.95
42 glass, stone, and clay prod	3.09	3.09	3.07	2.60	3.87
43 blast and basic steel prod	2.51	2.51	2.50	2.11	3.15
44 iron and steel found. and forging	2.51	2.51	2.49	2.11	3.14
46 nonfer. forge, cast, and rolling	2.54	2.54	2.52	2.13	3.17
47 fabricated metal containers	2.63	2.63	2.62	2.21	3.30
48 industrial and farm machinery	2.63	2.63	2.62	2.21	3.30
49 elec. equipment and components	2.59	2.59	2.57	2.18	3.24
50 truck, bus, and auto manufac.	2.77	2.78	2.76	2.33	3.48
51 misc transport. equipment	2.63	2.63	2.62	2.21	3.30
52 misc manufac.	2.50	2.50	2.48	2.10	3.13
53 railroads	2.54	2.72	2.30	2.14	3.18
54 misc transport. and communication	2.77	2.77	2.75	2.33	3.47
55 motor freight transport.	2.39	2.00	2.76	2.01	2.99
56 water transport.	1.46	1.46	1.44	1.23	1.82
57 air transport.	2.47	2.45	4.58	2.08	3.10
58 wholesale trade	2.15	2.15	2.13	1.81	2.69
59 retail trade	2.15	2.15	2.13	1.81	2.69
60 finance and insurance	2.87	2.87	2.85	2.41	3.59
61 real estate	2.87	2.87	2.85	2.41	3.59
62 hotels, lodging, and amusements	2.87	2.87	2.85	2.41	3.59
63 misc business and personal serv.	2.87	2.87	2.85	2.41	3.59
64 advertising	2.87	2.87	2.85	2.41	3.59
65 auto repair	2.87	2.87	2.85	2.41	3.59
66 medical and educational serv.	2.87	2.87	2.85	2.41	3.59
67 nonprofit organizations	2.87	2.87	2.85	2.41	3.59

Source: differential growth rates are based on CONAES(1978) which are adjusted (see text) to meet scenario growth rate assumptions.

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miles per capita has been increasing at a rate of acount 3 percent per annum.[16] All of the scenarios except 3, 5, and 5a assume that the growth rate in per capita final demand for automotive transportation (in vehicle-miles) is 2.4 percent per annum. In the low and high economic growth scenarios 5 and 5a, the growth rate is assumed to be 2.1 and 3.1 percent, respectively. In the zero energy growth scenario, this rate is assumed to be 2.4 percent per annum until 1985. In 2000, it is assumed that per capita vehicle miles for personal transportation falls back to the 1974 level.

2.4 Scenario Fuel Mix Assumptions

The scenario fuel mix assumptions, in general, have little impact upon total energy consumption, even though the assumptions are the most important determinates in individual fuel consumption. Table 5 contains the fuel-mix coefficients for the 1974 baseline data.[17] In all the scenarios except scenario 4, the gas scenario, it is assumed that there is a significant incentive to use coal instead of other fossil fuels. Because direct combustion of coal for the production of space and water heat is, in general, not environmentally sound, the switch to coal only has a major impact upon the production of industrial process heat.[18] In scenarios 1, 2, 3, 5, and ta, it is assumed that the percentage of process heat produced from coal rises from 28 percent in 1974 to 55 percent in 2000.[19] In scenario 6, the fuel mix for process heat does not significantly change from that in 1974 except that no process heat is generated by the relatively energy inefficient method of resistance heating. In the natural gas scenario, the greater amount of substitution for other fuels by natural gas is assumed to occur between 1985 and 2000. In scenario

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[16] Total vehicle miles have been increasing at a rate between 4 and 4.7 percent per annum since 1960. Since the average growth rate of the U.S. population between 1960 and 1970 was around 1.25 percent per annum, per capita vehicle miles have been increasing at a rate of around 3 percent per annum (20).

[17] The derivation of the fuel mix baseline is discussed in Chapter 2.

[18] Originally it was assumed that heat for clothes drying and the household preparation of food was included in the final demand for process heat. These energy demands were reallocated to the final demand for space heat; otherwise, a significant portion of clothes dryers would be assumed to be coal-fired. This aggregation is more plausible, since a household that uses natural gas for space heating will probably use gas for other heating applications in the household.

[19] This approximately corresponds to the change assumed in the 2000 NEP Referance Energy System diagram by Hermelee (21).

TABLE 5

FUEL SPLITS FOR SATISFYING BED[1] IN 1974

	Fuel Type[2]			
Energy Product	Coal	Oil	Gas	Electric
Ore-Reduction Feedstock	100	-	-	-
Chemical Feedstocks	2	73	25	-
Process Heat	28	21	42	9
Water Heat	-	5	75	20
Space Heat	4	37	57	2
Air Conditioning	-	-	5	95

1. Basic Energy Demands.

2. Percentage of BED satisfied by fuel type.

5 for the year 2000, 7 percent of all process heat is produced from coal, while 85 percent is produced from natural gas.[20]

The "push to coal" scenarios assume a widespread use of heat pumps for space heating. Since the net energy cost of space heating via heat pumps is approximately the same as the energy required in space heating by direct combustion of fossil fuels, the use of heat pumps would promote energy efficiency and would decrease dependency upon fuels that are more scarce. Since the vast majority of this electric demand would be satisfied by coal-steam generators, coal would indirectly displace the use of other fossil fuels. Also, the residual generation associated with the use of heat pumps will be less than that generated by the direct combustion of coal for space heating, since coal furnaces most likely will be uncontrolled. It is assumed that in all of the scenarios except 4 and 6 that heat pumps satisfy 37 percent of all space heating demand in the year 2000. Because the investment cost of space heating is relatively expensive (22), a considerable government subsidy would be necessary to encourage the installation of heat pumps. In the natural gas scenario, the use of gas for home heating increases from 57 percent in 1974 to 87 percent in the year 2000. After the fuel mix for space heat was specified, the fuel mix for water was determined. Households burning gas for space heating were assumed to use gas for water heat. Households with furnaces burning fuel oil were assumed to use electric water heaters.

2.5 Modification of Material Requirements in Nonenergy Goods Production

To incorporate the changes in production techniques which may occur under different real energy prices, the changes to the A_{nn} technical coefficients[21] of the CONAES study (23) have been transformed into the sectoring scheme of the ORBES energy demand model. Most scenarios used the transformed factor matrix[22] of CONAES scenario III (24). ORBES scenarios 6 and 4, respectively, use the transformed factor matrices of CONAES scenarios II and IC (25). Scenario IV assumes that overall real energy prices double and quadruple. Table 6 lists several of the important elements of the factor matrices.

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[20] It is assumed that the increased availability of natural gas begins in the early 1980's. At that point, it is assumed that all new plants will install equipment that burn natural gas to produce process heat. Essentially, it is assumed that the use of coal, oil, and electricity for process heat then declines at an average rate of depreciation of capital (assumed to be 5 percent per annum).

[21] A_{nn} represents the nonenergy inputs to the production of the nonenergy goods.

[22] The factor matrix is a square matrix of order 43 (which is the same as the order of A_{nn}). Each element of the factor matrix is multiplied by the corresponding element of the base year A_{nn} to yield the A_{nn} sub-matrix used in the scenario runs. As indicated in footnote 1, transformations which both aggregate and disaggregate the CONAES factor matrices must be determined to compute corresponding factor matrices using the ORBES sectoring scheme.

Complete tables which list the three factor matrices used in the ORBES scenarios are available on request. In CONAES scenario II, it is assumed that rail and motor freight transportation margins[23] increase and decrease, respectively, due to the price incentive to use more fuel economic forms of transportation. In the same scenario, it is assumed that lighter automobiles require more plastics and aluminum[24] and less steel. In the highest energy price scenario, it is assumed that recycling efforts will increase. Thus, it is assumed that plastics to food products will decrease in that scenario.[25]

2.6 A Sensitivity Example

An inconsistency in the non-automotive transportation efficiency assumptions can be seen in Table 3 [26]. In a manner similar to that used in the Brookhaven NEP-RES (26) and Hermelee (27), decreases in energy use per ton mile were assumed to be the same for water, air, truck, and rail transport.[27] Scenario 3 transportation efficiency assumptions were taken from CONAES scenario III (28). Thus, there is an inconsistency here because we assume a higher efficiency for rail transport in a scenario with cheaper energy prices. A more consistent assumption for scenario 1 would be to incorporate the non-automotive transportation efficiency assumptions from CONAES scenario III.[28] A first order approximation for a change in the transportation efficiency assumptions can be found by performing the following calculations. The relevant data can be found in the solution transactions matrices and technical coefficient matrices for scenario 1. Specifically, the data in row 6, columns

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[23] The transportation margins represent the average cost (per unit output) of transporting all input goods to the producing industry by each transportation mode. Wholesale and retail margins are defined in the same manner. Thus, once all of these margin costs have been subtracted from the other technical coefficients, these costs are represented in F.O.B. prices.

[24] Aluminum production is contained in the aggregate classification "other primary metals." A separate sector is not possible, since aluminum production in the ORBES region is so minute that production figures are not disclosed in the census publications.

[25] In Table 6, it is indicated that there would be a slight per unit increase in the use of plastics in food product production in CONAES scenario III. This erroneous figure was caused by a bug in the algorithm which transformed the factor matrices. After this error was corrected, it was found that only a few coefficients were affected by this defect in the algorithm. ORBES scenario 2 was rerun and the largest difference in energy consumption was an 0.08 percent decrease in coal consumption.

[26] See item "Transportation Efficiency Increases in 2000" in Table 3.

[27] The NEP-RES refers to the National Energy Plan Reference Energy System diagram. See the discussion in Chapter 5 on the relationship between the supply-product input-output model and the reference energy system.

[28] CONAES scenario III assumes a doubling of real fuel prices.

TABLE 6

ELEMENTS OF THE FACTOR MATRICES FOR SEVERAL IMPORTANT PRODUCT MIX CHANGES[1]

	CONAES SCENARIO		
	IV	III	II
Motor freight margins[2] to most industries	1.18	1.03	0.09
Rail margins to most industries	1.01	1.09	1.16
Plastic to truck, bus, an auto man.	2.10	3.20	4.20
Iron and steel to truck, bus, and auto man.	0.87	0.64	0.41
Other primary metals[3] to truck, bus, and auto man.	1.70	2.40	3.00
Plastics to food products	1.25	1.06	0.87

1. These factors are represented in terms of the sectoring scheme used in the ORBES energy demand model.

2. See text for the discussion of transportation and trade margins.

3. Includes aluminum production.

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15 through 18 of Tables A-1.2 and A-1.3 will be used. For air transportation, the baseline technical coefficient was 5. In scenario 1, a 20 percent efficiency increase in air transportation was assumed. Therefore, the modified technical coefficient becomes 5/1.2 = 4.16667. The energy intensity of rail transportation in CONAES scenario III is 0.97. Under this assumption, the technical coefficient becomes .97•5 = 4.85. In ORBES scenario 1, fuel consumed by rail transportation is 136.2 trillion Btu of refined petroleum. If, instead, the CONAES scenario III efficiency is used, then [(0.97•5)/(4.16667)] •136.2=158.5 trillion Btu would be consumed, or the increase in consumption would be:

$$\left(\frac{0.97 \cdot 5}{4.16667} - 1\right) \cdot 136.2 = 22.3 \; .$$

CONAES scenario III assumes energy intensity changes for water, air, and motor freight transportation are 1, 0.48, and 0.8, respectively, we have

$$\left(\frac{1 \cdot 5}{4.16667} - 1\right) \cdot 87.5 = 17.5$$

$$\left(\frac{0.48 \cdot 5}{4.16667} - 1\right) \cdot 203.1 = -86.1$$

$$\left(\frac{0.8 \cdot 5}{4.16667} - 1\right) \cdot 332.2 = -13.3$$

Thus, the net effect of these four changes is a decrease in refined petroleum consumption of 59.6 trillion Btu (or a 1.7 percent decrease in ORBES region refined petroleum production). Though this is a first order approximation, it is a good one, since running the model with these changes incorporated results reflecting a decrease of 60.2 trillion Btu. Such a close correspondence indicates that this technique to determine the effect of a perturbation in scenario parameters will be sufficient for our needs.

3. Analysis and Interpretation of Scenario Runs and General Conclusions

3.1 Introduction

The discussion of the results of the scenario runs proceeds as follows. The results of the runs for Scenario 2 for 1985 and 2000 are discussed in depth. An important emphasis in this discussion is how the various growth rates in production and income affects the demand for various forms of energy. Because the effect of growth assumptions works essentially the same way in all scenarios, this discussion is only necessary for Scenario 2. Because most scenarios tend to be perturbations of Scenario 2, the analysis of other scenarios are done by comparing the results with those of Scenario 2.

The measure of energy consumption which is used in the comparison of the scenarios is

$$te = cc + cr + cg + \frac{ph + pn}{\alpha} \qquad (3.1)$$

where
te = total energy
cc = consumption of coal
cr = consumption of refined petroleum
cg = consumption of natural gas
ph = production of hydro-electric power
pn = production of nuclear electric power
α = thermal conversion efficiency (assumed to be .34)

The term $(ph + pn)/\alpha$ represents the energy consumed in the production of electricity by hydro and nuclear power in terms of the amount of fossil fuels required to produce an equivalent amount of electric power. It should be noted that this is not the only possible measure. Another approach would net out interregional transfers in energy forms. In some comparisons such a definition is more plausible for as we shall see some of the variations in aggregate fuel consumption between scenarios can be explained by interregional transfers of energy form (most importantly electricity). With the energy supply-product model the most meaningful way of doing this is to determine the amount of energy supply categories required to satisfy total regional energy product demands.[29] Once these energy supply demands are determined a formula similar to (3.1) is used to determine total energy consumption. The measure given in (3.1) is a more physical measure. Loosely it represents the amount of energy that is actually burned (consumed) in a region.

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[29] Note that by definition energy product demands are not exported.

Appendix tables B-1 through B-6 contain the solutions vectors of the scenario runs. Final demand, total production, and total consumption by industry are listed. Net exports can be found by subtracting total consumption from total production. Also the energy supply to supply and energy supply to energy product sub-matrices of the technical coefficient and transactions matrices are printed.[30] Appendix C contains summary tables of results by fuel and end use.

3.2 Energy Consumption Patterns in Scenario 2

Using the measure of (3.1), the total energy consumption for scenario 2 is 12,781 trillion Btu in 1985 and 15.151 trillion Btu in 2000. Since total energy consumption is 10,311 trillion Btu in 1974, the average total energy growth rate[31] is higher between 1974 and 1985 than over the 1985-2000 period. The reduction in the growth in total energy consumption can best be explained after some detailed discussion on the consumption of individual fuel forms.

In scenario 2, ORBES consumption of natural gas and refined petroleum in 1985 does not change substantially from the 1974 levels. For refined petroleum the small change in consumption can be explained as follows. Growth in non-automotive transportation demand closely tracks the increase in GRP. Since the assumed growth rate of 2.5 percent per annum translates into a 32 percent increase over a period of 11 years, a 9 percent increase in non-automotive transportation fuel efficiency will reduce fuel consumption in these sectors to an overall increase of around 20 percent. Because it is assumed that the growth in per capita annual vehicle miles for personal (final demand) automotive transportation rises at approximately the same rate as GRP, with a 20 mph[32] average fuel efficiency the net effect is an 8 percent drop in refined petroleum consumed by automotive transportation. The consumption of refined petroleum in space heating falls when oil space heating furnaces are replaced by electric heat pumps. It is assumed that approximately 13 percent of all furnaces burning fuel oil are replaced by heat pumps. It is assumed that a negligible amount of newly installed productive capacity will consume refined petroleum to produce process heat. Finally, it is assumed that only refined petroleum is used in the generation for peak electric demand.[33] Though there is a decrease in consumption of refined petroleum for space heating and personal automotive transportation, the net result is that total refined petroleum consumption increases because of the increases in the consumption by non-automotive transportation and by utilities for peak generation.

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[30] In the notation of Chapter 1 these are, respectively, A_{ss}, A_{sp}, T_{ss}, and T_{sp} sub-matrices. In the corresponding tables, columns 1 through 12 contain the energy supply to supply sub-matrix while columns 13 through 24 contain the energy supply to product sub-matrix.

[31] We define the average growth rate α as the parameter fitted to $e^{\alpha t} = x$.

[32] The national average fuel efficiency for automobiles in the mid-1970's was around 13.5 mpg.

[33] We have assumed that peak electric demand that must be satisfied by gas or oil turbine generators which amounts to 5 percent of total fossil generation.

Before discussing the 1985 consumption of natural gas, it is important to note that transmission loss in the input-output model in 1974 has been allocated to the gas utility industry, while in the 1985 and 2000 model, it is allocated to the crude oil and gas sector. Thus, for the purpose of comparison, the 109 trillion Btu in 1974 should actually be subtracted from the consumption of natural gas and added to the consumption of crude oil and natural gas. After doing so, it is seen that the consumption of natural gas increases by a slight amount. Although some gas water heaters have been replaced by electric, most of the expansion in the demand for space heating has been met by natural gas. Also it is assumed that a small amount of new productive capacity will burn natural gas to produce process heat.

Coal consumed in the production of electricity, process heat, and ore-reduction feedstocks accounts for over 95 percent of total ORBES coal consumption. The largest percent increase in coal consumption is associated with process heat requirements. This is close to the assumption that most newly installed industrial capacity will burn coal. The second largest increase is associated with electric generation,[34] while coal used for ore-reduction feedstocks rises only slightly. This is due in part to a 4 percent enduse efficiency increase and the assumption that electric arc techniques will replace blast furnace production. Coal consumption by the coal industry[35] increases because of the losses associated with beneficiation. This loss is assumed to be 0.5 percent of total coal production.

The relatively high production of electricity is in part due to the assumption that historic consumption patterns for the demand for miscellaneous electric power use will prevail. Also, part of the increase is due to the assumption that households and the commercial sector will begin to install heat pumps to provide space heat. Most of the newly installed water heaters are assumed to be electric. The demand for electricity for air conditioning rises by 56 percent. Though the increase in air conditioning market penetration in the industrial and commercial sector is not as large as the increase in the residential sector,[36] approximately half of the growth in the air conditioning demand occurs in the industrial and commercial sector because of the effect of economic growth. The aggregate growth in the regional consumption of electricity rises by 3.6 percent per annum from 1974 to 1985.

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[34] If the model is solved for fossil electric production given the same ratio of exports to production used in other runs (24 percent), then fossil electric production would be approximately 1,430 trillion Btu instead of 1,587 trillion Btu.

[35] Some of the direct transactions from coal to coal represent transportation loss.

[36] See items concerning air conditioning market penetration in Table 2.1.

In the 1985 runs of the ORBES energy demand model it was assumed that each element of the final demand vector grew on the average at the same rate as the growth in GRP (29). In the 2000 runs, the CONAES weights for differential growth rates were incorporated into the model. Thus, in the 2000 runs, there is a relative increase in the production of services as compared to industrial consumption. Since on a dollar per dollar basis, the energy intensity of a purchase of a service is, in general, less than the energy intensity of a purchase of manufactured goods, we expect to find a decrease in the growth rate of energy consumption over the 1985-2000 period. As previously noted, electricity exports are assumed to be relatively high in 1985.[37] In 2000, the ratio of exports to production of electricity is assumed to decrease to the 1974 ratio. Also the enduse efficiency increases that are assumed to occur between 1985 and 2000 dampen energy consumption.

Gas consumption falls between 1985 and 2000. This is due in part to the assumption that, after 1985, the use of heat pump technology for space heating becomes widespread. The majority of the new additions to the housing stock are assumed to install heat pump technology to produce space heating. Gas water heaters are also being displaced by electric units. Also, it is assumed that the direct combustion of coal will continue to displace natural gas in the production of process heat.

Total refined petroleum consumption rises slightly between 1985 and 2000. Though automotive efficiencies are assumed to be 27 mpg in 2000, gasoline consumption by automobiles increases slightly, due to the assumed 2.4 percent annual growth rate in per capita vehicle miles. The demands for freight transportation modes except water[38] grow approximately at the same rate as GRP. A 7 percent increase in the fuel efficiency of these freight transportation modes is assumed to occur between 1985 and 2000; fuel use by these transportation modes increases approximately 2 percent per annum between 1985 and 2000. After efficiency increases are netted out, approximately 20 percent of the process heat produced by refined petroleum has been displaced by coal. Also, approximately 30 percent of the oil space heat furnaces in 1985 have been replaced by heat pumps in the year 2000. Most of the increase in the demand for refined petroleum for the production of chemical feedstocks is due to the CONAES assumption of an increase in the consumption of asphalt by the construction industry. The net effect on ORBES consumption of refined petroleum is a 6 percent increase in refined petroleum consumption from 1985 to 2000.

In scenario 2, the consumption of natural gas decreases 9 percent in 2000 from the amount consumed in 1985. The decrease in consumption of natural gas for space heating is for the most part due to an increase in enduse efficiency, though a small portion of the reduction is due to the replacement of gas furnaces by heat pumps. About 4 percent of the process heat that was produced by natural gas in 1985 has been replaced by either coal or electric resistance heating. Also, the trend of replacing old gas water heaters by electric heaters is assumed to continue.

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[37] Fossil fuel consumption would be reduced by 462 trillion Btu if the 1985 fossil electric exports were assumed to be at "historic" levels. The total energy consumption growth rate would then be 1,7 percent per annum.

[38] The CONAES study (30) assumes that water transportaion margins are assumed to be 0.72 of the 1974 values. This followed from the assumption that the growth rates for water freight transport are 0.38 times the GNP growth rate.

The significant rise in coal consumption from 1985 to 2000 is mostly due to the assumption that 55 percent of process heat will be generated by direct coal combustion in the year 2000. The consumption of coal in the production of ore-reduction feedstocks rises only slightly, since it is assumed that most new iron and steel production facilities will use the electric arc process. Hydroelectric and nuclear electric power production is assumed not to increase in scenario 2 from the amount produced in 1985. Thus, a greater share of electricity must be produced by coal-fired plants. But this is checked by the assumption that exports relative to production will decrease in the year 2000 as compared to 1985.

Total ORBES consumption of electric power increases approximately 50 percent from 1985 to 2000. About half of this increase is due to the increase in miscellaneous electric power demand, which grows at a rate of 2.1 percent per annum[39] between 1985 and 2000. Nearly 20 percent of this increase is due to the substitution of electric heat pumps for the generation of space heat. The rest of the increase is fairly evenly distributed among ore-reduction feedstocks, process heat, and water heat.

In terms of the parameter changes which implement the various scenario descriptions in the energy demand model, scenario 2 can be considered as the base case scenario, and scenarios 1, 2, 3, 5, and 5a are perturbations of this scenario. Scenario 1 is different from scenario 2 only in environmental controls. Scenarios 5 and 5a are different only in that different growth rates for final demand are assumed. Scenario 3 assumes that alternative energy technologies are used to satisfy basic energy product demands. The conventional technology fuel mix assumptions and growth rates are the same as those in scenario 2.

3.3 Energy Consumption in Scenario 1

The fuel mix, enduse efficiency, and other economic assumptions in scenario 1 are the same as those contained in scenario 2, except for the conversion efficiencies for coal combustion. The environmental controls in scenario 1 are stricter than those of scenario 2. Thus, it is assumed in scenario 1 that the conversion efficiency of coal into electricity or process heat is lower by 2 percent, due to the need to reheat flue gas after scrubbing. This results in an additional 166 trillion Btu of coal being consumed by the fossil electric power sector in the year 2000. Similar efficiency reductions are assumed for process heat produced from coal in scenario 1. Besides very minor second order effects on fuel consumption, there are no other differences in the runs for scenarios 1 and 2.

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[39] Miscellaneous electric power demanded by the industrial and the commercial sectors grows at a rate of 2.4 percent per annum between 1985 and 2000.

3.4 Energy Consumption in Scenario 3

The energy produced by the alternative technologies that are specified in scenario 3 satisfy specific energy enduses. The input-output equations are specifically written[40] so that the consumption of conventional energy supplies are determined as a residual in a set of simultaneous equations. That is, given (1) a vector of final demand, (2) assumptions which determine net exports, and (3) the specified levels of energy product demands that are satisfied by alternative energy supplies, the set of simultaneous equations determines the amount of conventional energy supplies that must be consumed to satisfy the energy product demands that are not satisfied by the alternative energy technologies. Note that the A_{sp} submatrix only specifies the fuel mix for the energy product demands that are to be satisfied by conventional fuels.

The amounts of the alternative technology energy sources that are to be consumed were derived from estimates developed by the TASE project[41] (31). Schiffman (32) contains tables which disaggregate the national totals into state shares. The state totals were then prorated by the most relevant components of Page's (33) ORBES region GRP estimates. Table 7 contains the ORBES totals for the various alternative energy supply technologies examined in the TASE project. The centralized production of electricity from solar energy is allocated to the central station electric power sector. This power is supplied to the power grid and displaces fossil electric power production. An 8.8 percent transmission loss is associated with all centralized electricity production. Decentralized electric generation by windmills is assumed to satisfy miscellaneous electric power demand with no transmission loss. Except for the assumed level of market penetration of air conditioning, the efficiency and conventional technology fuel mix assumptions are the same as those in scenario 2. Only a 10 percent increase in the per capita demand for air conditioning by households is assumed in scenario 3. Also, the amount of air conditioning consumed per unit output in the industrial and commercial sectors is assumed to increase by 5 percent in scenario 3.

The total consumption of conventional fuels in scenario 3 is 13,189 trillion Btu, which is approximately 87 percent of total energy consumption in

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[40] See the last section of Chapter 1, which discusses the two forms of the energy demand model that are used in this study.

[41] Technology Assessment of Solar Energy (TASE). Several scenarios were developed. We have used their "Maximum Practical" scenario. In this national scenario, solar energy displaces 14 quads of fossil fuels in the nation.

TABLE 7

AMOUNT OF ENERGY PRODUCT DEMANDS DISPLACED BY ALTERNATIVE TECHNOLOGIES IN SCENARIO 4

Technology	BED[1]	Percent[2]
Electric Utilities		
Biomass	22	8.00
Photovoltaic Conversion	1	0.04
Solar Thermal	7	0.30
Wind	57	2.00
Decentralized Wind Elec. Gener.	16	0.60
Process Heat from Biomass	381	20.00
Solar Process Heat	118	6.00
Active Solar Space Heat	98	10.00
Passive Solar Space Heat	14	1.00
Space Heat from Wood	22	2.00
Solar Water Heat	72	33.00

1. All units are in trillion BTU's. Output of electric generation technologies are measured in electricity generated. All other figures represent Basic Energy Demand (BED) satisfied.

2. Percentages for Electric Generations are relative to total ORBES production of Electricity. All other percentages represent the portion of total consumption of energy products which is satisfied by an alternative technology.

scenario 2.[42] The most significant reduction in conventional fuel use is in coal, which drops by approximately 1,500 trillion Btu. This is mostly due to the reduction in fossil electric consumption[43] although 400 trillion Btu of coal are displaced in the production of process heat. Approximately 400 trillion Btu of natural gas is displaced by alternative energy sources. More specifically, 200, 40, and 160 trillion Btu of natural gas is displaced in the production of process, water, and space heats. Refined petroleum consumption is reduced by 200 trillion Btu. Most of the displacement occurs in the production of process and space heating, where gas consumption falls by 80 and 150 trillion Btu, respectively. Due to the decrease in demand for conventional electricity production, the oil consumed in peak electric generation falls by 60 trillion Btu.[44]

3.5 Natural Gas Scenario

Scenario 4 could be viewed as the most optimistic scenario in terms of energy prices. Because of the assumed relative abundance of natural gas in this scenario, there is a significant incentive to substitute this fuel in all energy uses except for electricity production. Being the most energy optimistic scenario, the enduse efficiency increases were relatively small. As compared to 1974 baseline, the total enduse efficiency increase for process and space heating was assumed to be 5 and 7 percent, respectively.[45] This increase in the supply of natural gas is assumed to occur after 1985. Thus, there are no major differences in the fuel mix for scenario 4 in 1985 and the baseline fuel mix. After 1985 it is assumed that additions to the capital stock will consume natural gas rather than other fuels. The consumption of other fuels in the production of process and space heat is assumed to decline with the depreciation and replacement of the capital stock that utilizes these fuels. This rate of depreciation was assumed to be 5 percent per annum. By this assumption, 85 percent of the basic energy demand for process heat was satisfied by natural gas. The rest of the demand for process heat was split between coal, refined petroleum, and electric with the respective percentages of 7, 6, and 2 percent. For space and water heating, it was assumed that approximately 15 percent of the demand could not be satisfied by gas utilities. In such cases it was assumed that heating oil was used for space heating and hot water was supplied by electric heaters.

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[42] Using the market penetration assumptions for air conditioning of scenario 2, total energy consumption would be 13,330 trillion Btu.

[43] The reader should keep in mind that any drop in ORBES electric consumption has a multiplier effect upon production since exports also drop.

[44] Peak electric production has only been allocated in fossil electric production. It would have been more satisfactory to allocate some natural gas or refined petroleum consumption to all central station electric production technologies, since large coal plants, nuclear plants, or the alternative technology plants cannot economically provide peaking capacity.

[45] Increases of 10 and 15 percent, respectively, in the average enduse efficiency for process and space heat was assumed in scenario 2.

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In comparing the aggregate energy consumption of scenarios 2 and 4, the most significant difference is, of course, in natural gas consumption. In scenario 2, natural gas consumption is 1,960 trillion Btu, while it is 5,390 trillion Btu in scenario 4. The majority of the difference in natural gas consumption in these two scenarios comes from the demand for natural gas in the production of space heat. In scenario 4, 2,752 trillion Btu of natural gas are consumed, while in scenario 2, only 762 trillion Btu are used. Most of the rest of the difference can be accounted for in the production of process heat. In scenario 4, 1,852 trillion Btu of natural gas is consumed, as compared to 929 trillion Btu in scenario 2.

The largest change in fuel use in this scenario is coal consumption. Because of the reduction of electric power generation and the reduction of the use of coal in the production of process heat, total coal consumption in scenario 4 is 5,895 trillion Btu, as compared to 8,967 trillion Btu in scenario 2. Of this 3,000 trillion Btu difference, approximately 1,700 trillion Btu is due to the reduced consumption of coal in the generation of electricity, while the rest is due to the reduction of the use of coal in the production of process heat.

Vis à vis scenario 2, the consumption of refined petroleum increases from 3,503 trillion Btu to 3,632 trillion Btu in scenario 4. In several uses, though, the consumption of refined petroleum did decline. Due to the substitution by natural gas, refined petroleum consumption in the production of process heat is 120 trillion Btu lower in scenario 4 than in scenario 2. Also, 372 trillion Btu is eliminated in peak electrical generation. These decreases were offset by increased consumption in the transportation sectors. Much of this increase in the consumption of refined petroleum in transportation uses is attributed to lower efficiencies.[46] Auto gasoline consumption is 1,716 trillion Btu in scenario 4, instead of 1,267 trillion Btu as in scenario 2. Nearly all of this increase can be attributed to lower automotive efficiencies. The consumption of refined petroleum in air transportation in scenario 4 is 370 trillion Btu, as compared to 203 trillion Btu in scenario 2. This increase is mostly due to an increase in the final demand for air transportation, though some is due to an increase in the freight margin that is apportioned to air transport.[47]

Total electricity consumption in scenario 4 is 1,409 trillion Btu, which is 25 percent lower than in scenario 2. The most significant factor that contributes to this reduction is that plentiful gas supplies make electric heating, whether resistance or heat pump, noncompetitive. This factor accounts for 179 trillion Btu of the difference. Because 15 percent of the water heat in scenario 4 is assumed to be produced by electric heaters; in scenario 2, the percentage is 65, or 107 trillion Btu less consumption of electricity. The other major factor responsible for the lower consumption of electricity is that 10 percent of process heat in scenario 2 is produced by electric, while in scenario 4, the percentage is 2. This results in 147 trillion Btu less consumption of electricity in the production of process heat.

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[46] The average auto efficiency is assumed to be 28 mpg in scenario 2, while 21 mpg is assumed in scenario 4 in year 2000. For other transportation modes, a 10 instead of 20 percent average efficiency increase is assumed in scenario 4.

[47] CONAES scenario C (34) was used to determine increases in the final demand expenditures, along with nonenergy technical coefficient and transportation margin changes. CONAES scenario C was an optimistic energy scenario in which no change in real energy prices was assumed to occur.

3.6 Alternative Growth Rate Scenarios

Scenarios 5 and 5a provide a measure of the sensitivity of energy consumption with respect to economic growth. The reader is warned that the measure is a crude one. Most important, this test should not be construed as an answer to the question: what portion of economic growth can be attributed to the use of energy? It is assumed in these scenarios that growth occurs only by an increase in labor productivity. In scenarios 1 through 5, we have assumed that labor productivity has increased in such a manner as to allow an average annual growth rate of 2.47 percent per annum. Besides the fact that the people are assumed to be better workers in the year 2000, we have essentially assumed[48] that input material requirements are the same as that of 1974. Since, cateris paribus, if labor productivity increases x percent and if leisure does not increase, GRP will increase by x percent. If material input requirements do not change, then the consumption of all goods should rise by the same percentage when the composition of final demand does not change. Therefore, if nothing else changes, one just multiplies all consumption figures by the growth in GRP.

The motivation behind the alternative growth rate scenarios is to provide some insight into the relationship between increases in energy consumption and personal income. In scenarios 5 and 5a, we have assumed that the demand for space and water heat by households does not change with the growth rate assumptions. That is, it is assumed that the increase in real energy prices is large enough that the consumption of these goods becomes income inelastic. The final demand for personal transportation is assumed to have a unitary income elasticity and, thus, grows at the same rate as the increase in GRP. Also, we have incorporated the CONAES differential growth rates for the final demand for nonenergy goods and services. The growth in the individual elements of GRP are determined in a two-step process. In the first step, the following formula is used to adjust the differential growth rates so that they are approximately consistent with the overall growth in GRP.

$$g_o = \frac{\ln G_c \cdot \alpha}{0.02 \cdot 43} \qquad (3.2)$$

The term g_o is the growth rate of a specific element of a sector in the final demand vector to be scaled in the second step; G_c is the overall growth in the corresponding element of the CONAES final demand vector from 1967 to 2010 (a period of 43 years). The term 0.02 represents the growth rate in GNP assumed in the CONAES scenarios. The growth rate is α (in percent per annum) of overall GRP. These growth rates are then applied to the individual elements of the final demand vector. The resulting vector is then scaled by a constant so that the overall growth rate is consistent with the assumed growth rate of GRP.[49] The intuition behind (3.2) is that the elasticity of the various components of final demand with respect to the growth in GRP can be determined from the differential growth factors developed in the CONAES study; (3.2) is an approximation[50] to the growth rate of a specific element of final demand given a different growth rate of income (or GRP).

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[48] Except for some minor changes in input requirements which were incorporated from the CONAES integration model.

The total energy consumption in scenarios 2, 5, and 5a, respectively, are 15,150, 13,970, and 17,360 trillion Btu. Since percentage decrease in energy consumption between scenarios 5 and 2 is -7.8 percent, while the percentage decrease in GRP is -9.4 percent, the elasticity of energy consumption with respect to GRP is 0.83. The elasticity computed from the differences in scenario 2 and 5a is 0.82.

For the most part, growth in the consumption of individual fuels in scenarios 5 and 5a mirror the economic growth rates. There are some discrepancies that do arise. One important factor which induces slight increase in the consumption of coal is due to fixed output assumptions for nuclear and hydroelectric power. The effect of this assumption is to increase the consumption of coal in that a greater portion of electric demand is satisfied by coal steam generation at higher levels of electricity consumption. Also, the residential consumption of fuels tends to be smaller in scenario 5 since the low population (due to inmigration assumptions) estimate of Milke (35) was used. There is no similar effect in scenario 5a, since Milke's base case population growth estimate is used. Another assumption which tends to increase refined petroleum consumption is that the per capita final demand for automobile transportation grows at essentially the same rate as GRP. With positive rates of population growth, this assumption increases petroleum consumption. Compared with scenario 2, the consumption of individual fuel types are, respectively, -8.3, -7.5, -6.8, and -7.1 percent lower in scenario 5 for coal, refined petroleum, natural gas, and electricity. For scenario 5a, the respective increases are 15.3, 14.4, 16.7, 12.6, and 12.8 percent. Again, the reader is cautioned not to read too much into the sensitivity analysis for the experiment has assumed that differences in growth rates only occur by different labor productivities.

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[49] The vector resulting in the first step needs to be adjusted only by two or three percent.

[50] Actually (3.2) is a first order approximation because the actual growth rate is time varying. The actual growth factor should be:

$$G_o = G_c^{\phi} \qquad \text{where } \phi = \frac{e^{\alpha t} - 1}{e^{02 \cdot 43} - 1} .$$

3.7 "Wheeling of Power"

The models for scenarios 2 and 2a are identical, except that in scenario 2a, electric power generation from coal plants is specified to be 2,546 trillion Btu.[51] This amount is equal to the total generation from coal plants in scenario 2 plus 20,000 megawatts additional capacity operating at a 50 percent plant factor. Almost all of the increase in electricity production is exported.[52] This results in 890 trillion Btu more coal consumption in scenario 2a as compared to scenario 2. Due to peaking capacity fuel requirements, refined petroleum consumption in scenario 2a is 62 trillion Btu larger than in scenario 2. The consumption of electric power produced by coal plants increases by 50 trillion Btu though 25 trillion Btu of the increase is due to line loss. Natural gas consumption is only 7 trillion Btu larger in scenario 2a.

3.8 Conservation Scenario

Scenario 6 was an attempt to determine total energy consumption when maximum practical enduse efficiencies were assumed. The enduse efficiency increases were assumed to be: 45 percent for space heat, 35 percent for process heat, and 40 percent increase for air conditioning. Average automobile fuel efficiencies were assumed to be 37 mpg. On a per capita basis, the final demand for personal automobile transport was assumed to be equal to that in 1974. Transportation efficiencies of 55 percent, 40 percent, and 9 percent are assumed for air, truck, and rail transport, respectively.[53] It is assumed that 140 trillion Btu of electricity is generated from coal steam plants that cogenerate the equivalent of 154 trillion Btu of basic energy demand (BED) for process heat. Also, 70 trillion Btu of BED for process heat and 28 trillion Btu of BED for space heat is satisfied by these total energy systems. With the assumed increases in enduse efficiencies and the assumed levels of production of cogenerated electric power, total energy consumption in scenario 6 is 10,531 trillion Btu. This is only two percent larger than the 1974 energy consumption baseline.

The above discussion has stressed the detailed way in which changes in energy and fuel use occurred as well as in the magnitude of associated changes. The interested reader is referred to Table 8 for a convenient summary of the 1974-2000 percent changes in energy and fuel use, by scenario, as well as the average annual compounded growth rates, 1974-2000. Figures 4

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[51] The model in scenario 2a determined net exports of electric power from coal plants rather than total regional production as in scenario 2.

[52] ORBES-region electricity consumption does increase slightly due to the increase in indirect demands required by the increase in electric power production.

[53] CONAES (1978) scenario II was used as a guide for determining enduse efficiencies for the transportation sector.

FIGURE 4

Coal Use, by Scenario, in the ORBES Region, 10^{12} Btu

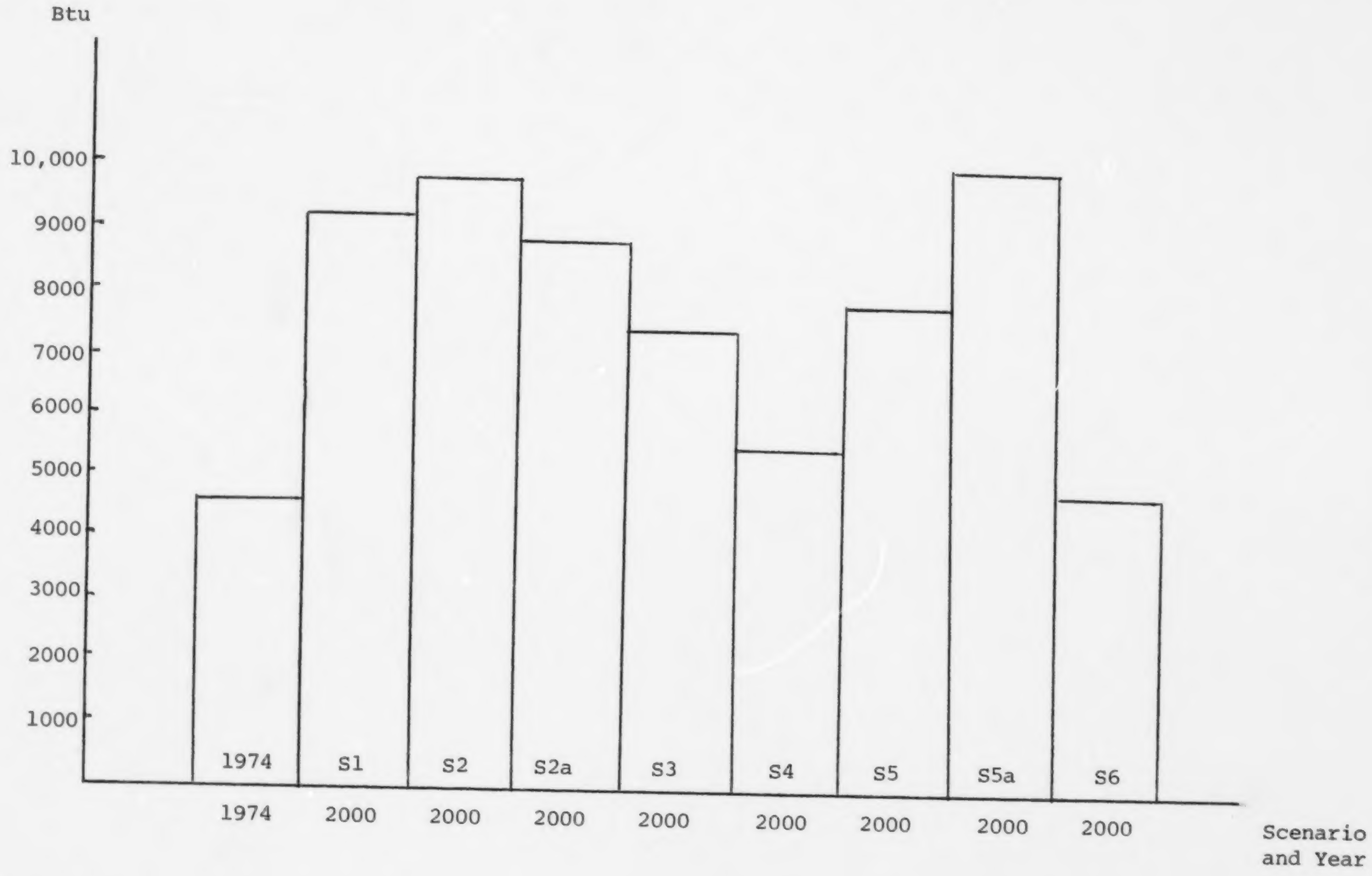


FIGURE 5

Refined Petroleum Use, by Scenario, in the ORBES Region, 10^{12} Btu

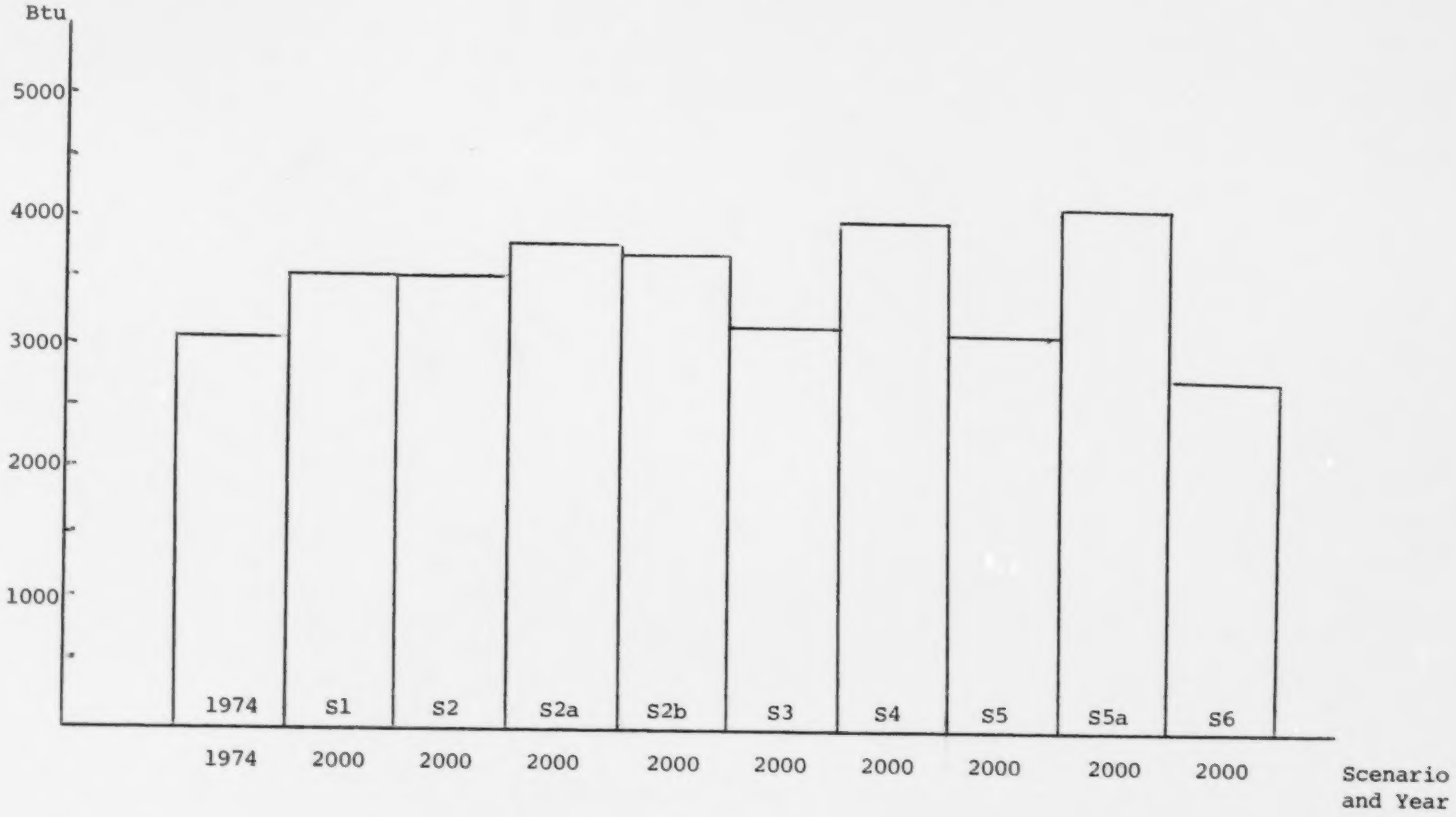


FIGURE 6

Natural Gas Use, by Scenario, in the ORBES Region, 10^{12} Btu

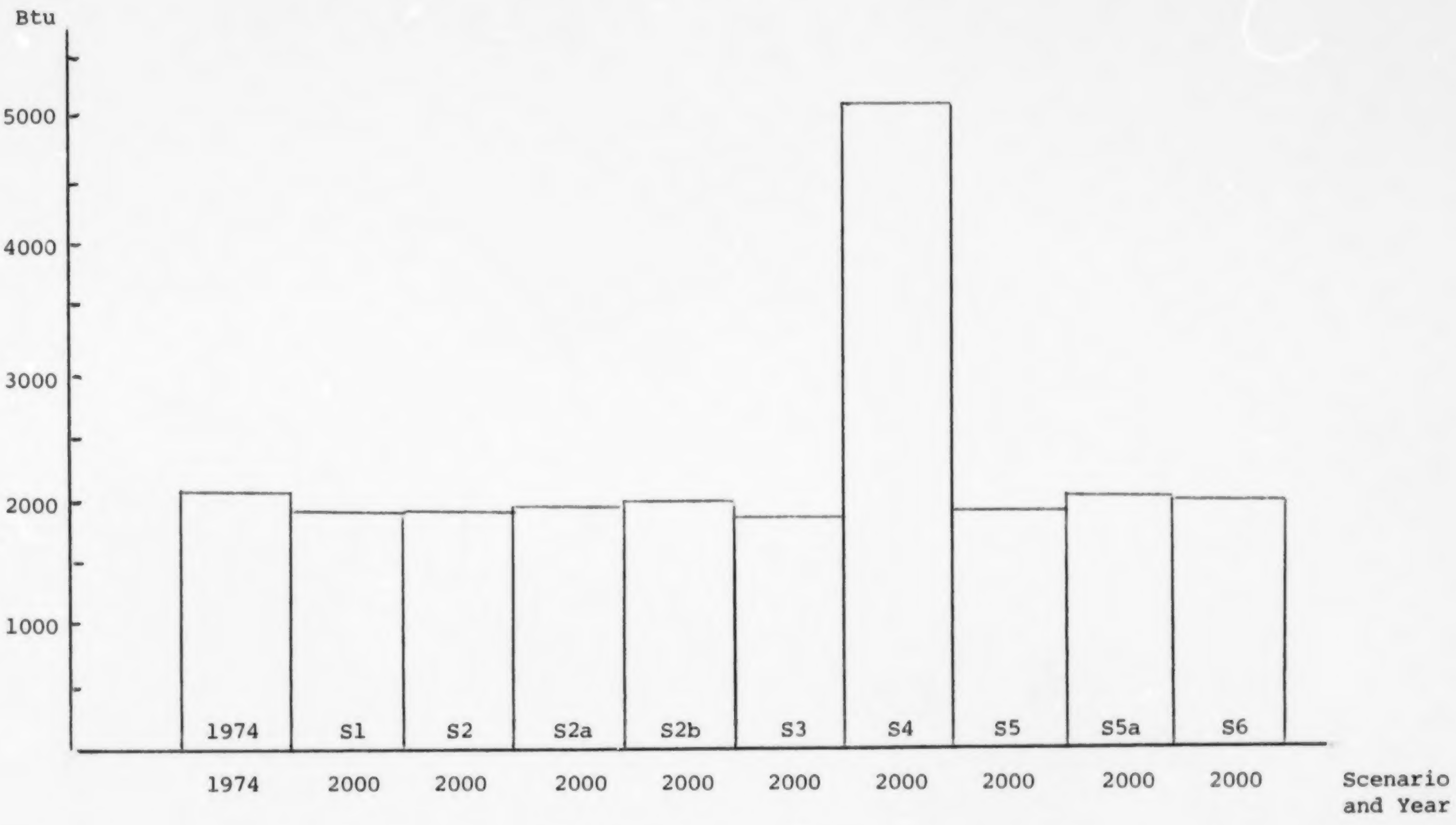


FIGURE 7

Electric Use, by Scenario, in the ORBES Region, 10^{12} Btu

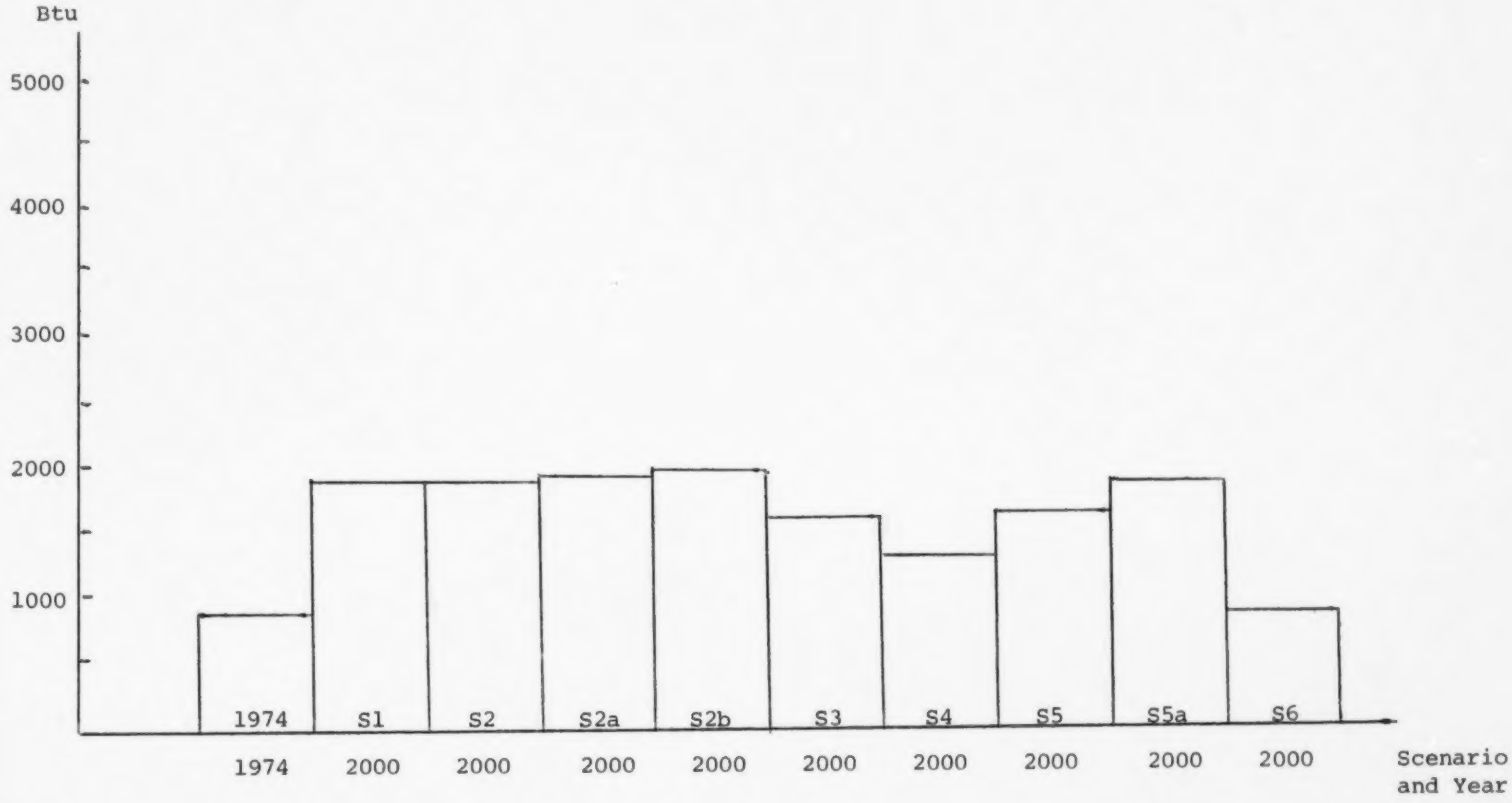
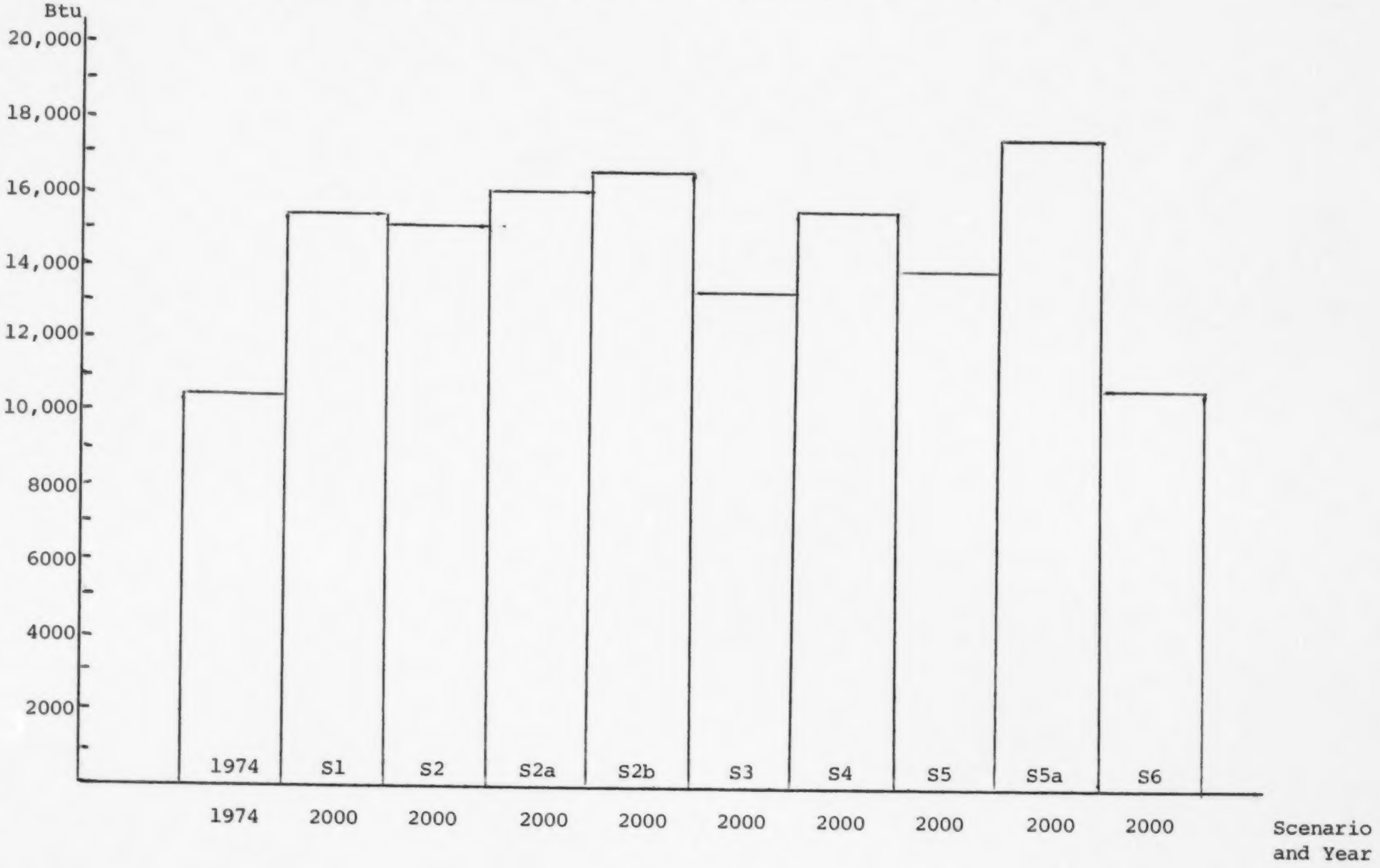


FIGURE 8

Total Fuel Use, by Scenario, in the ORBES Region, 10^{12} Btu



through 8 provide visual representation of the data contained in Table 8. Figures 4 through 6 relate to, respectively, coal, refined petroleum products, and natural gas use, while Figure 7 is for electric (fossil fuel equivalent), and Figure 8 is for total energy and fuel use.

TABLE 8

REGIONAL CONSUMPTION OF ENERGY AND FUEL USE, BY SCENARIO, IN THE ORBES REGION*

10^{12} Btu

		Coal	% Change 1974-2000	Refined Petroleum	% Change 1974-2000	Natural Gas	% Change 1974-2000	Electric	% Change 1974-2000	Total (fossil fuel eq.)	% Change 1974-2000
S1											
	1974	4,842		3,186		2,176		842		10,311	
	1985	6,736	88.6	3,287	10	2,157	-9.9	1,250	123	12,900	48.6
	2000	9,133	(2.47)	3,504	(0.37)	1,961	(-0.40)	1,878	(3.13)	15,317	(1.53)
S2											
	1974	4,842		3,186		2,176		842		10,311	
	1985	6,617	85.2	3,287	10	2,156	-9.9	1,250	123	12,781	46.9
	2000	8,967	(2.40)	3,503	(0.37)	1,960	(-0.40)	1,878	(3.13)	15,151	(1.49)
S2a											
	1974	4,842		3,186		2,176		842		10,311	
	1985	--	103.6	--	11.9	--	-9.6	--	126.8	--	56.2
	2000	9,857	(2.77)	3,565	(0.43)	1,967	(-0.39)	1,910	(3.20)	16,109	(1.73)
S3											
	1974	4,842		3,186		2,176		842		10,311	
	1985	--	56.3	--	4	--	-27	--	99.5	--	27.9
	2000	7,567	(1.73)	3,312	(0.15)	1,589	(-1.20)	1,680	(2.69)	13,190	(0.95)
S4											
	1974	4,842		3,186		2,176		842		10,311	
	1985	5,158	21.1	3,556	14	2,769	147.7	1,099	67.3	12.203	51.4
	2000	5,865	(0.74)	3,632	(0.51)	5,390	(3.55)	1,409	(2.00)	15,609	(1.61)

(continued)

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TABLE 8 (continued)

		Coal	% Change 1974-2000	Refined Petroleum	% Change 1974-2000	Natural Gas	% Change 1974-2000	Electric	% Change 1974-2000	Total (fossil fuel eq.)	% Change 1974-2000
S5											
	1974	4,842		3,186		2,176		842		10,311	
	1985	--	69.6	--	1	--		--	107.2	--	35.5
	2000	8,214	(2.05)	3,215	(0.03)	1,825	(-0.67)	1,745	(2.84)	13,974	(1.18)
S5a											
	1974	4,842		3,186		2,176		842		10,311	
	1985	--	113.6	--	28.4	--	1.5	--	151.8	--	68.4
	2000	10,343	(2.96)	4,090	(0.97)	2,208	(0.01)	2,120	(3.62)	17,362	(2.02)
S6											
	1974	4,842		3,186		2,176		842		10,311	
	1985	--	5.3	--	-13.2	--	-7.8	--	26.2	--	2.7
	2000	5,097	(0.20)	2,767	(-0.54)	2,006	(-0.31)	1,063	(0.90)	10,591	(0.10)

*Figures in ( ) are the average annual compounded growth rates.

4. Some General Conclusions

The preceeding discussion of model results stressed the reasons *why* there were observed differences as between scenario runs. In some cases, observed differences were uniquely attributable to a single changed condition (export of electricity, for example), while in other cases there were complex changes in parameter values which accounted for differences in output (the conservation scenario contrasted with scenario 2). In terms of the orientation of certain scenarios, it is also possible to draw some general conclusions with respect to total energy and fuel use in the ORBES region. The reader must bear in mind that for most such statements the reasons for large observed differences are complex and relate to reasonably detailed changes in parameter values of the model.

Contrasting total energy use in the region by scenario (Table 8 and Figure 8) supports the following general conclusions:

1. Strict pollution control standards are largely irrelevant with respect to anticipated energy use. This conclusion follows from comparing scenarios 2 and 1.
2. A relatively strong conservation scenario (scenario 6) produces dramatically less energy use in the region as compared with the base case scenario (scenario 2).
3. An alternative technology scenario (scenario 3) suggests substantially less energy use in the region than under base case conditions, but not as much less as the conservation scenario (scenario 6).
4. Total energy use in the region is relatively sensitive to alternative specifications concerning economic growth rates (scenario 2 as compared with scenarios 5 and 5a).

Other methods of implementing the scenarios might well produce different results, although we believe the qualitative differences between scenarios would probably remain unchanged.

Focusing on total energy use, of course, masks the differences discussed earlier among particular fuels. Figures 4, 5, 6, and 7 and Table 8 support the following general conclusions:

1. Coal is the fuel most sensitive to alternative scenario specifications. As was the case with total regional consumption of fuels and energy, the greatest degree of sensitivity is to conservation, alternative technology, and assumptions about economic growth. Unlike the case of total energy use, coal use in the region is highly sensitive to assumptions in the natural gas scenario (scenario 4).

2. Natural gas use, except for the case of scenario 4, is largely independent of scenario specifications.

3. Refined petroleum use, like coal use, is most sensitive to conservation, alternative technology, and economic growth scenarios.

4. Electric use, for the most part, is sensitive to the following scenarios: conservation, natural gas, alternative technology, and alternative growth rates.

As discussed earlier, many of these general statements concerning individual fuels are a direct result of the way in which the scenarios were implemented.

Appendix A

Determining the Energy Demand Model's Sectoring Scheme by Sensitivity Analysis

There is always a problem of dimensionality in modeling large scale systems. While it is usually useful to economize on the number of parameters that need to be determined in a large scale model, severe aggregation may hide some of the more important internal relationships. We discuss below a technique which permits an economy of data collection and identifies those parameters which must be determined with the greatest degree of precision.

Sensitivity analysis of linear equations can be subdivided into two general procedures. The first, which would be termed tolerance analysis, is used to determine the effect of random fluctuations of all of the parameters on the solution of the system of equations. The analysis usually involves Monte Carlo simulations which relate the level of disaggregation with the degree of numerical instability (36). The second procedure involves the perturbation of each parameter in order to determine the effect on an element, or on several elements, of the solution. This is the procedure that is particularly useful for determining the key parameters (37) in a system of equations, and, therefore, for determining the most important technical coefficients in an input-output model with respect to energy consumption.

In the following discussion, the sensitivity equation is derived. The result was originally deduced by Sherman and Morrison (38), though the paper only verified the result for a change of a single element. A general discussion of the derivation is useful, for it will demonstrate a general technique that can easily be extended to the determination of the change in the solution when several parameters are simultaneously modified.

Let $B=(I-A)$ and δB be nxn matrices whose elements are all zero except for the element in position (i,j). This element is represented by δb_{ij}. Suppose that x is the solution of

$$Bx = y \tag{3.5}$$

and z is the solution of

$$(B+\delta B)z = y \,. \tag{3.6}$$

Premultiplying (3.6) by B^{-1}, we have

$$(I+B^{-1}\delta B)z = B^{-1}y = x \,. \tag{3.7}$$

Written out explicitly, $(I + B^{-1}\delta B)$ is of the form:

$$\begin{pmatrix} 1\ 0\ \cdots & \bar{b}_{1j}\delta b_{ij} & 0\ \cdots & \\ 0\ 1\ 0\ \cdots & \bar{b}_{2i}\delta b_{ij} & 0\ \cdots & \\ \cdots & \cdots & \cdots & \\ \cdots\ 0 & 1+\bar{b}_{ji}\delta b_{ij} & 0\ \cdots & \\ & \vdots & & \\ 0\ \cdots & \bar{b}_{ni}\delta b_{ij} & 0\ \cdots & 0\ 1 \end{pmatrix}$$

where $(\bar{b}_{kl}) = B^{-1}$. It follows directly that

$$z_j = \frac{x_j}{1 + \bar{b}_{ji}\delta b_{ij}} = \frac{x_j}{1 - \bar{b}_{ji}\delta a_{ij}} \tag{3.8}$$

because $\delta b_{ij} = -\delta a_{ij}$. For

$$z_k = x_k - \bar{b}_{ki}\delta b_{ij}x_j = x_k - \frac{\bar{b}_{ki}\delta b_{ij}x_j}{1 + \bar{b}_{ij}\delta b_{ij}} . \tag{3.9}$$

Because (3.8) can be rewritten as

$$z_j = x_j + \frac{\bar{b}_{ij}\delta a_{ij}}{1 - \bar{b}_{ji}\delta a_{ij}} , \tag{3.10}$$

the perturbation in the j^{th} element of the solution vector is of the same form as the perturbation of any other element (3.9). By approximating (3.9) by the first two terms of the equivalent geometric series expansion,

$$\frac{\bar{b}_{ki}\delta a_{ij}x_j}{1 - \bar{b}_{ji}\delta a_{ij}} \cong \bar{b}_{ki}\delta a_{ij}x_j + \bar{b}\delta a_{ij}x_j\bar{b}_{ji}\delta a_{ij} \tag{3.11}$$

If the perturbation of a_{ij} is small, the change in the k^{th} element of the solution vector can be approximated by

$$\bar{b}_{ki}\delta a_{ij}x_j \quad . \tag{3.12}$$

As the present application is concerned only with changes in the total output of the energy industries, only values of the index k that correspond to the energy industries are of interest.

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Using (3.12), we can define an n^{th} order sensitivity matrix S^k, whose elements are used to approximate the change in the total output of the k^{th} industry when the corresponding element in the A matrix is perturbed. S^k is an n^{th} order square matrix whose element in position (i,j) represents the factor by which the relative change in corresponding technical coefficient is multiplied by to give the approximate change in total output of the k^{th} industry. If S^k_{ij} is the element in the (i,j) position of the matrix S^k, then

$$S^k_{ij} = \bar{b}_{ki} a_{ij} x_j = \bar{b}_{ki} t_{ij} \ . \tag{3.13}$$

This definition of the sensitivity matrix is particularly useful in the identification of the key technical coefficients that must be determined with the greatest precision.

Suppose that an input-output model is to be principally used to forecast output of a small number of industries. Because input-output modeling requires a relatively large amount of data collection, it is particularly worthwhile if an industrial classification scheme could be found that kept sectors with relatively sensitive technical coefficients disaggregate while classifying the relatively insensitive sectors in a more aggregate manner.

The approach which should be used to find such a classification is very dependent on the industries of primary interest. If one is primarily interested in the total output of some capital goods industry, say laundry equipment, a reasonable classification scheme can be found for an input-output model of the order of ten to twenty sectors. In this model, all of the important sectors will be kept disaggregate, while the very appreciable aggregation of the rest of the economy does not swamp the importance of the disaggregate sectors. The aggregation can be found directly from the sort of the elements of the sensitivity matrix.

In the case of energy production, the specification of the aggregation is not as straightforward. The procedure used in the preceding example will result in an aggregation in which the aggregate industries will become as important and sometimes much more important than those industries that have been left disaggregate. It is also possible that an industry has no single particularly sensitive technical coefficient, but has a large number of technical coefficients of moderate sensitivity. Therefore, the sensitivity analysis of entire row and column changes are of considerable importance. By perturbing each row and column of the A matrix, new sensitivity relations can be deduced.

Support that the elements of the j^{th} column of the A matrix have been multiplied by the constant (1+c). The exact solution to the new system of equations can be found by the same procedure used in the derivation of the sensitivity relation for a single element. If z and x are the solutions to the perturbed and unperturbed systems of equations, respectively, then

$$z_j = \frac{x_j}{1 - (\bar{b}_{jj} - 1)c} \tag{3.14}$$

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and for

$$z_k - x_k = \frac{c\bar{b}_{kj}x_j}{1 - (\bar{b}_{jj}-1)c} \cong c\bar{b}_{kj}x_j \ . \qquad (3.15)$$

Note, though, that the column sum of the sensitivity matrix is

$$\sum_i \bar{b}_{ki}a_{ij}x_k - \bar{b}_{kj}x_j + \bar{b}_{kj}x_j =$$

$$\sum_j \bar{b}_{ki}a_{ij}x_j + \bar{b}_{ki}(a_{ij}-1)x_j + \bar{b}_{kj}x_j = \bar{b}_{kj}x_j \qquad (3.16)$$

The second equality holds because the inner product between the j^{th} column of (I-A) and the i^{th} row of the inverse is zero. Therefore, the column sum of the sensitivity matrix provides a first-order approximation for the perturbation of output due to a scalar change in the corresponding column of the A matrix, though is is far more computationally efficient to use (3.15).

The sensitivity relation for the perturbation of the i^{th} row of the A matrix can be found by an analogous solution perturbation technique (39). If z and x are the perturbed and unperturbed solution vectors, respectively, then

$$z_k = x_k + \bar{b}_{ki}\phi \qquad (3.17)$$

where

$$\phi = \frac{c(x_i - y_i)}{1 + c(1-\bar{b}_{ii})} \ . \qquad (3.18)$$

Therefore,

$$z_k - x_k \cong \bar{b}_{ki}c(x_i - y_i). \qquad (3.19)$$

Note that the row sum of the sensitivity matrix is

$$\sum_i \bar{b}_{ki}t_{ij} = \bar{b}_{ki}(x_i - y_i) \ . \qquad (3.20)$$

By the comparison of the row and column sensitivity relations, (3.19) and (3.15), it is evident that output is always more sensitive to a column change than the same size row change. This, of course, does not hold for the change in x_k when the k^{th} row is perturbed. Therefore, the column perturbation relation $\bar{b}_{ki}x_i$ is chosen to the sensitivity relation used in determing the aggregation scheme.

The 357[54] terms, $\bar{b}_{ki}x_i$, were ranked and sectors whose value of $\bar{b}_{ki}x_i$ were less than 450 trillion Btu were left unaggregated[55]. There were 34 such industries. The other sectors were then aggregated into major industrial classes. The philosophy followed in the aggregation of the other sectors was

1. Similar industries should only be aggregated into the same industry.
2. The column sensitivity of the aggregated industries should be on the order of the industries left unaggregated.
3. Energy output should not be sensitive to diagonal elements where it is not expected that self-use in direct production is not important.

It was found that 23 aggregate industries were necessary if the column sensitivity of the aggregate industries were to be on the same order as the unaggregated industries.

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[54] The base input-output matrix was the 357-order 1967 national energy input-output matrix developed by the energy group at CAC. All energy transactions are in trillion Btu, while all other transactions are in million dollars.

[55] $\bar{b}_{ki}x_i$ has the dimension of 10^{12} Btu. Because the total energy consumption of the U.S. in 1967 was 5.8×10^{16} Btu, the cutoff point of 4.5×10^{14} implies that industries were considered important if their sensitivity relation was approximately 1 percent of total energy output. Note that $\bar{b}_{ki}x_i$ approximates the change in the total output of the k^{th} industry when the coefficients in the i^{th} column are doubled. Because the exact change is found by (3.16), $\bar{b}_{ki}x_i$ underapproximates the actual change. It was not necessary to rank the sensitivity relations corresponding to the refined petroleum, gas, and electric utilities. Because of the inefficiencies of the energy conversion processes, the sensitivity with respect to crude petroleum and gas total output was always larger than with respect to the product industries (refined petroleum, gas, and electric utilities).

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APPENDIX B

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(PREVIOUSLY CIN. EPA FORM 287)
TYPING GUIDE SHEET

TABLE B-1.1
Baseline Data, 1974, and Scenario 1 Solutions to the ORBES Energy Demand Model, 1985 and 2000*

	final demand			total production			total consumption		
	1974	1985	2000	1974	1985	2000	1974	1985	2000
1 coal mining	0	0	0	10964	15254	20682	4842	6736	9133
2 crude petroleum, gas	0	0	0	683	722	703	5429	5738	5587
3 shale oil	0	0	0	0	0	0	0	0	0
4 gasified coal	0	0	0	0	0	0	0	0	0
5 solvent-refined coal	0	0	0	0	0	0	0	0	0
6 ref'd petroleum products	0	0	0	2109	2175	2319	3186	3287	3504
7 natural gas utilities	0	0	0	3302	3273	2975	2176	2157	1961
8 coal combined cycle elec.	0	0	0	0	0	0	0	0	0
9 fossil electric utilities	0	0	0	1074	1587	2233	814	1083	1692
10 nuclear elect. utilities	0	0	0	23	210	210	18	143	159
11 high-temp gas reactor	0	0	0	0	0	0	0	0	0
12 renewable elec. util's	0	0	0	13	35	35	10	24	27
13 ore-reduction feedstocks	0	0	0	215	282	390	215	282	390
14 chemical feedstocks	12	17	26	325	434	704	325	434	704
15 water transport	0	0	0	15	19	21	15	19	21
16 air transport	0	0	0	26	34	49	26	34	49
17 truck, bus transport	0	0	0	45	60	80	45	60	80
18 rail transport	0	0	0	17	22	33	17	22	33
19 auto transport	240	331	506	254	349	532	254	349	532
20 misc. thermal uses	0	0	0	1190	1542	2150	1190	1542	2150
21 water heat	113	119	127	166	190	227	166	190	227
22 space heat	486	515	550	787	912	1117	787	912	1117
23 air-conditioning	69	102	139	126	195	289	126	195	289
24 misc. elec. power uses	163	190	221	543	692	940	543	692	940
25 agriculture	827	1085	1290	8393	11015	13529	7312	9597	11787
26 mining	14	18	26	688	908	1292	1422	1876	2669
27 construction	11071	14527	21335	10562	13897	20339	13051	17172	25134
28 meat products	2260	2965	3239	2102	2758	3080	2747	3605	4026
29 food exc. meat products	6614	8679	9800	10603	13915	16963	9384	12315	15013
30 apparel and misc text. prod	455	597	846	302	397	569	1508	1982	2842
31 misc fabricated text. prod	2329	3056	4267	1162	1526	2137	2783	3653	5115
32 logging and misc. wood prod	885	1161	1666	1875	2465	3451	2412	3171	4440
33 misc paper prod and publ.	937	1230	1731	3257	4284	5984	2961	3894	5439
34 paper mills	37	48	67	431	567	794	732	963	1348
35 paperboard mills	1	1	1	248	326	436	391	515	689
36 paperboard containers	22	28	40	825	1083	1425	851	1118	1471
37 industrial org-inorg chem.	180	236	336	2644	3612	5306	2322	3172	4660
38 ag and misc chem.	1246	1635	2322	3026	4019	6302	2743	3643	5711
39 plastic and synthetic resins	14	19	26	1286	1697	2410	954	1259	1788
40 paving and asphalt	2	2	3	177	232	542	129	170	397
41 rubber and misc plastic prod	867	1138	1601	4163	5475	8578	2633	3463	5426
42 glass, stone, and clay prod	109	142	242	3586	4718	6736	1996	2626	3749
43 blast and basic steel prod	94	123	180	10475	13786	19081	5351	7043	9748
44 iron and steel found. and forging	12	16	24	1727	2272	3099	1304	1716	2341
45 other primary metal manufac.	0	0	0	657	866	1254	1566	2063	2988
46 nonfer. forge, cast, and rolling	58	77	113	3200	4209	6187	2129	2800	4116
47 fabricated metal containers	1005	1318	1992	6510	8562	12067	5683	7475	10535
48 industrial and farm machinery	3308	4341	6558	10506	13815	20302	7026	9239	13577

*Sectors 1-24 in trillions of Btu's; industries 25-67 in millions of 1967 dollars.

BOTTOM OF IMAGE AREA: OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
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TABLE B-1.1 (continued)

	final demand			total production			total consumption		
	1974	1985	2000	1974	1985	2000	1974	1985	2000
49 elec. equipment and components	3085	4048	6042	9635	12666	18565	6605	8684	12728
50 truck, bus, and auto manufac.	3403	4465	7001	6698	8792	13673	5751	7550	11740
51 misc transport. equipment	3093	4059	6132	2957	3881	5808	4004	5256	7866
52 misc manufac.	1382	1813	2643	1573	2066	3011	2274	2986	4352
53 railroads	406	533	786	1874	2495	3695	1874	2495	3695
54 misc transport. and communication	1989	2610	4087	3780	4950	7353	3780	4950	7353
55 motor freight transport.	669	878	1246	2387	3142	4441	2387	3142	4441
56 water transport.	224	294	327	566	738	819	566	738	819
57 air transport.	455	597	866	527	692	1004	527	692	1004
58 wholesale trade	4269	5602	7460	7333	9639	13146	8107	10656	14533
59 retail trade	11029	14472	19273	12470	16377	21994	12563	16498	22158
60 finance and insurance	3329	4368	7015	5008	6580	10139	5795	7615	11733
61 real estate	9559	12543	20143	9487	12447	19193	14106	18507	28537
62 hotels, lodging, and amusements	1751	2298	3690	2895	3802	5754	3577	4699	7111
63 misc business and personal serv.	2201	2888	4639	3712	4878	7289	5015	6592	9849
64 advertising	22	29	47	1187	1562	2177	2215	2915	4061
65 auto repair	1072	1407	2259	1606	2112	3189	1879	2471	3731
66 medical and educational serv.	4630	6076	9757	4409	5786	9280	4754	6238	10005
67 nonprofit organizations	1298	1703	2735	1684	2210	3499	1493	1959	3102

*Sectors 1-24 in trillions of Btu's; industries 25-67 in millions of 1967 dollars.

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TABLE B-1.2

Baseline Data, 1974, and Scenario 1 Solutions to the ORBES Energy Demand Model, 1985 and 2000: Associated Transaction Matrices (trillions of Btu's)

	1	2	3	4	5	6	7	8	9	10	11	12
1	8.6 76.0 103.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	3358.5 4907.7 6312.8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
2	0.0 0.0 0.0	16.9 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	2109.5 2364.5 2520.2	3302.3 3373.7 3067.3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
6	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	64.4 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	87.9 283.4 372.1	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
7	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	109.6 0.0 0.0	0.0 0.0 0.0	42.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
9	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	94.5 138.0 194.2	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
10	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	2.0 18.3 18.3	0.0 0.0 0.0	0.0 0.0 0.0
11	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
12	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	1.2 3.0 3.0

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TABLE B-1.2 (continued)

	13	14	15	16	17	18	19	20	21	22	23	24
1	922.7 928.4 1044.6	7.9 10.5 70.4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	478.5 787.0 1601.9	0.0 0.0 0.0	65.2 26.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
2	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
6	0.0 0.0 0.0	238.8 314.7 478.6	72.5 86.0 87.5	128.0 152.7 203.1	225.4 270.7 332.2	82.9 100.3 136.2	1268.7 1163.1 1267.1	373.6 382.0 289.5	12.9 12.4 0.0	631.3 521.9 337.3	0.0 0.0 0.0	0.0 0.0 0.0
7	0.0 0.0 0.0	81.3 108.3 154.8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	788.3 851.5 759.3	198.0 169.0 120.2	950.6 1027.9 926.5	6.2 0.0 0.0	0.0 0.0 0.0
8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
9	0.0 51.6 97.5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	100.4 116.6 175.9	32.5 62.1 126.7	17.1 53.8 161.2	43.8 61.8 89.4	525.6 599.2 847.5
10	0.0 6.8 9.2	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	2.2 15.4 16.5	0.7 8.2 11.9	0.4 7.1 15.2	0.9 8.2 8.4	11.3 79.3 79.7
11	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
12	0.0 1.1 1.5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	1.2 2.6 2.8	0.4 1.4 2.0	0.2 1.2 2.5	0.5 1.4 1.4	6.5 13.2 13.3

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TABLE B-1.3

Baseline Data, 1974, and Scenario 1 Solutions to the ORBES Energy Demand Model, 1985 and 2000: Associated Technical Coefficient Matrices (dimensioned Btu's input per Btu's output)

	1	2	3	4	5	6	7	8	9	10	11	12
1	0.00079	0.00000	0.00000	1.62000	1.69700	0.00000	0.00000	2.10872	3.12811	0.00000	0.00000	0.00000
	0.00498	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.09245	0.00000	0.00000	0.00000
	0.00498	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.82738	0.00000	0.00000	0.00000
2	0.00000	0.02470	0.00000	0.00000	0.00000	1.00040	1.00022	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	1.08696	1.03093	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	1.08696	1.03093	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.03053	0.00000	0.00000	0.08184	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.17857	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.16667	0.00000	0.00000	0.00000
7	0.00000	0.00000	0.00640	0.03319	0.00000	0.00000	0.03319	0.00000	0.03909	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.14837	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08800	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696	0.00000	0.00000	0.00000
10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08801	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696	0.00000	0.00000
11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.09000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08815
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696

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TABLE B-1.3 (continued)

	13	14	15	16	17	18	19	20	21	22	23	24
1	4.30000	0.02428	0.00000	0.00000	0.00000	0.00000	0.00000	0.40212	0.00000	0.08283	0.00000	0.00000
	3.28723	0.02428	0.00000	0.00000	0.00000	0.00000	0.00000	0.51051	0.00000	0.02848	0.00000	0.00000
	2.67685	0.10000	0.00000	0.00000	0.00000	0.00000	0.00000	0.74509	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.73438	5.00000	5.00000	5.00000	5.00000	5.00000	0.31393	0.07789	0.80215	0.00000	0.00000
	0.00000	0.72585	4.54545	4.54545	4.54545	4.54545	3.33333	0.24781	0.06521	0.57220	0.00000	0.00000
	0.00000	0.68000	4.16667	4.16667	4.16667	4.16667	2.38095	0.13465	0.00000	0.30197	0.00000	0.00000
7	0.00000	0.24985	0.00000	0.00000	0.00000	0.00000	0.00000	0.66242	1.19153	1.20776	0.04906	0.00000
	0.00000	0.24986	0.00000	0.00000	0.00000	0.00000	0.00000	0.55234	0.89084	1.12704	0.00000	0.00000
	0.00000	0.22000	0.00000	0.00000	0.00000	0.00000	0.00000	0.35316	0.52910	0.82955	0.00000	0.00000
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08437	0.19538	0.02172	0.34611	0.96712
	0.18284	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.07564	0.32753	0.05895	0.31737	0.86627
	0.24984	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08182	0.55784	0.14433	0.30913	0.90112
10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00182	0.00422	0.00047	0.00747	0.02088
	0.02419	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01001	0.04334	0.00780	0.04200	0.11463
	0.02350	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00769	0.05246	0.01357	0.02907	0.08475
11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00105	0.00242	0.00027	0.00429	0.01200
	0.00403	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00167	0.00722	0.00130	0.00700	0.01910
	0.00392	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00128	0.00874	0.00226	0.00485	0.01412

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BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS

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EPA-287 (Cin.)
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TABLE B-2.1

Baseline Data, 1974, and Scenario 2 Solutions to the ORBES Energy Demand Model, 1985 and 2000*

	final demand			total production			total consumption		
	1974	1985	2000	1974	1985	2000	1974	1985	2000
1 coal mining	0	0	0	10964	14986	20307	4842	6617	8967
2 crude petroleum, gas	0	0	0	683	722	703	5429	5737	5587
3 shale oil	0	0	0	0	0	0	0	0	0
4 gasified coal	0	0	0	0	0	0	0	0	0
5 solvent-refined coal	0	0	0	0	0	0	0	0	0
6 ref'd petroleum products	0	0	0	2109	2175	2318	3186	3287	3503
7 natural gas utilities	0	0	0	3302	3272	2975	2176	2156	1960
8 coal combined cycle elec.	0	0	0	0	0	0	0	0	0
9 fossil electric utilities	0	0	0	1074	1587	2232	814	1083	1692
10 nuclear elect. utilities	0	0	0	23	210	210	18	143	159
11 high-temp gas reactor	0	0	0	0	0	0	0	0	0
12 renewable elec. util's	0	0	0	13	35	35	10	24	27
13 ore-reduction feedstocks	0	0	0	215	282	390	215	282	390
14 chemical feedstocks	12	17	26	325	434	704	325	434	704
15 water transport	0	0	0	15	19	21	15	19	21
16 air transport	0	0	0	26	34	49	26	34	49
17 truck, bus transport	0	0	0	45	60	80	45	60	80
18 rail transport	0	0	0	17	22	33	17	22	33
19 auto transport	240	331	506	254	349	532	254	349	532
20 misc. thermal uses	0	0	0	1190	1541	2149	1190	1541	2149
21 water heat	113	119	127	166	190	227	166	190	227
22 space heat	486	515	550	787	912	1117	787	912	1117
23 air-conditioning	69	102	139	126	195	289	126	195	289
24 misc. elec. power uses	163	190	221	543	692	940	543	692	940
25 agriculture	827	1085	1290	8393	11015	13529	7312	9597	11787
26 mining	14	18	26	688	908	1292	1422	1876	2669
27 construction	11071	14527	21335	10562	13896	20338	13051	17171	25132
28 meat products	2260	2965	3239	2102	2758	3080	2747	3605	4026
29 food exc. meat products	6614	8679	9800	10603	13915	16963	9384	12315	15013
30 apparel and misc text. prod	455	597	846	302	397	569	1508	1982	2842
31 misc fabricated text. prod	2329	3056	4267	1162	1526	2136	2783	3653	5115
32 logging and misc. wood prod	885	1161	1666	1875	2464	3450	2412	3170	4439
33 misc paper prod and publ.	937	1230	1731	3257	4284	5983	2961	3894	5439
34 paper mills	37	48	67	431	567	794	732	963	1348
35 paperboard mills	1	1	1	248	326	436	391	515	689
36 paperboard containers	22	28	40	825	1083	1425	851	1118	1471
37 industrial org-inorg chem.	180	236	336	2644	3610	5304	2322	3171	4658
38 ag and misc chem.	1246	1635	2322	3026	4019	6301	2743	3642	5711
39 plastic and synthetic resins	14	19	26	1286	1697	2410	954	1259	1787
40 paving and asphalt	2	2	3	177	232	542	129	170	397
41 rubber and misc plastic prod	867	1138	1601	4163	5474	8576	2633	3462	5424
42 glass, stone, and clay prod	109	142	242	3586	4717	6734	1996	2625	3748
43 blast and basic steel prod	94	123	180	10475	13781	19074	5351	7040	9744
44 iron and steel found. and forging	12	16	24	1727	2271	3098	1304	1716	2340
45 other primary metal manufac.	0	0	0	657	865	1254	1566	2062	2987
46 nonfer. forge, cast, and rolling	58	77	113	3200	4208	6186	2129	2799	4115
47 fabricated metal containers	1005	1318	1992	6510	8560	12064	5683	7473	10532
48 industrial and farm machinery	3308	4341	6558	10506	13810	20294	7026	9236	13572

*Sectors 1-24 in trillions of Btu's; industries 25-67 in millions of 1967 dollars.

BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
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TABLE B-2.1 (continued)

	final demand			total production			total consumption		
	1974	1985	2000	1974	1985	2000	1974	1985	2000
49 elec. equipment and components	3085	4048	6042	9635	12665	18563	6605	8683	12727
50 truck, bus, and auto manufac.	3403	4465	7001	6698	8792	13673	5751	7549	11740
51 misc transport. equipment	3093	4059	6132	2957	3881	5808	4004	5256	7866
52 misc manufac.	1382	1813	2643	1573	2066	3011	2274	2986	4352
53 railroads	406	533	786	1874	2494	3694	1874	2494	3694
54 misc transport. and communication	1989	2610	4087	3780	4949	7353	3780	4949	7353
55 motor freight transport.	669	878	1246	2387	3141	4440	2387	3141	4440
56 water transport.	224	294	327	566	738	818	566	738	818
57 air transport.	455	597	866	527	692	1004	527	692	1004
58 wholesale trade	4269	5602	7460	7333	9637	13144	8107	10655	14532
59 retail trade	11029	14472	19273	12470	16376	21993	12563	16497	22156
60 finance and insurance	3329	4368	7015	5008	6579	10138	5795	7614	11732
61 real estate	9559	12543	20143	9487	12445	19190	14106	18503	28532
62 hotels, lodging, and amusements	1751	2298	3690	2895	3801	5753	3577	4698	7110
63 misc business and personal serv.	2201	2888	4639	3712	4878	7288	5015	6591	9847
64 advertising	22	29	47	1187	1562	2176	2215	2914	4060
65 auto repair	1072	1407	2259	1606	2112	3189	1879	2471	3731
66 medical and educational serv.	4630	6076	9757	4409	5786	9280	4754	6238	10005
67 nonprofit organizations	1298	1703	2735	1684	2210	3499	1493	1959	3102

*Sectors 1-24 in trillions of Btu's; industries 25-67 in millions of 1967 dollars.

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TABLE B-2.2
Baseline Data, 1974, and Scenario 2 Solutions to the ORBES Energy Demand Model, 1985 and 2000:
Associated Transaction Matrices (trillions of Btu's)

	1	2	3	4	5	6	7	8	9	10	11	12
1	8.6 74.6 101.1	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	3358.5 4807.6 6182.6	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
2	0.0 0.0 0.0	16.9 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	2109.5 2364.2 2519.8	3302.3 3373.2 3066.8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
6	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	64.4 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	87.9 283.4 372.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
7	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	109.6 0.0 0.0	0.0 0.0 0.0	42.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
9	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	94.5 138.0 194.1	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
10	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	2.0 18.3 18.3	0.0 0.0 0.0	0.0 0.0 0.0
11	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
12	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	1.2 3.0 3.0

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TABLE B-2.2 (continued)

	13	14	15	16	17	18	19	20	21	22	23	24
1	922.7 928.1 1044.2	7.9 10.5 70.4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	478.5 770.7 1568.7	0.0 0.0 0.0	65.2 26.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
2	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
6	0.0 0.0 0.0	238.8 314.7 478.5	72.5 86.0 87.4	128.0 152.7 203.1	225.4 270.5 332.1	82.9 100.3 136.1	1268.7 1163.1 1267.1	373.6 381.9 289.4	12.9 12.4 0.0	631.3 521.8 337.2	0.0 0.0 0.0	0.0 0.0 0.0
7	0.0 0.0 0.0	81.3 108.3 154.8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	788.3 851.2 759.0	198.0 169.0 120.2	950.6 1027.8 926.4	6.2 0.0 0.0	0.0 0.0 0.0
8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
9	0.0 51.6 97.5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	100.4 116.6 175.8	32.5 62.1 126.7	17.1 53.8 161.2	43.8 61.8 89.4	525.6 599.1 847.3
10	0.0 6.8 9.2	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	2.2 15.4 16.5	0.7 8.2 11.9	0.4 7.1 15.2	0.9 8.2 8.4	11.3 79.3 79.7
11	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
12	0.0 1.1 1.5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	1.2 2.6 2.8	0.4 1.4 2.0	0.2 1.2 2.5	0.5 1.4 1.4	6.5 13.2 13.3

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TABLE B-2.3
Baseline Data, 1974, and Scenario 2 Solutions to the ORBES Energy Demand Model, 1985 and 2000:
Associated Technical Coefficient Matrices (dimensioned Btu's input per Btu's output)

	1	2	3	4	5	6	7	8	9	10	11	12
1	0.00079	0.00000	0.00000	1.62000	1.69700	0.00000	0.00000	2.10872	3.12811	0.00000	0.00000	0.00000
	0.00498	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.02934	0.00000	0.00000	0.00000
	0.00498	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.76968	0.00000	0.00000	0.00000
2	0.00000	0.02470	0.00000	0.00000	0.00000	1.00040	1.00022	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	1.08696	1.03093	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	1.08696	1.03093	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.03053	0.00000	0.00000	0.08184	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.17857	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.16667	0.00000	0.00000	0.00000
7	0.00000	0.00000	0.00640	0.03319	0.00000	0.00000	0.03319	0.00000	0.03909	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.14837	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08800	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696	0.00000	0.00000	0.00000
10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08801	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696	0.00000	0.00000
11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.09000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08815
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696

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TABLE B-2.3 (continued)

	13	14	15	16	17	18	19	20	21	22	23	24
1	4.30000 3.28723 2.67685	0.02428 0.02428 0.10000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.40212 0.50009 0.72988	0.00000 0.00000 0.00000	0.08283 0.02848 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
2	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
3	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
4	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
5	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
6	0.00000 0.00000 0.00000	0.73438 0.72585 0.68000	5.00000 4.54545 4.16667	5.00000 4.54545 4.16667	5.00000 4.54545 4.16667	5.00000 4.54545 4.16667	5.00000 3.33333 2.38095	0.31393 0.24781 0.13465	0.07789 0.06521 0.00000	0.80215 0.57220 0.30197	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
7	0.00000 0.00000 0.00000	0.24985 0.24986 0.22000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.66242 0.55234 0.35316	1.19153 0.89084 0.52910	1.20776 1.12704 0.82955	0.04906 0.00000 0.00000	0.00000 0.00000 0.00000
8	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
9	0.00000 0.18284 0.24983	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.08437 0.07564 0.08182	0.19538 0.32753 0.55782	0.02172 0.05895 0.14432	0.34611 0.31737 0.30913	0.96712 0.86627 0.90110
10	0.00000 0.02419 0.02350	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00182 0.01001 0.00770	0.00422 0.04334 0.05247	0.00047 0.00780 0.01358	0.00747 0.04200 0.02908	0.02088 0.11463 0.08476
11	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
12	0.00000 0.00403 0.00392	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00105 0.00167 0.00128	0.00242 0.00722 0.00875	0.00027 0.00130 0.00226	0.00429 0.00700 0.00485	0.01200 0.01910 0.01413

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(4-76)

TABLE B-3.1
Baseline Data, 1974, and Scenario 4 Solutions to the ORBES Energy Demand Model, 1985 and 2000*

	final demand			total production			total consumption		
	1974	1985	2000	1974	1985	2000	1974	1985	2000
1 coal mining	0	0	0	10964	11682	13283	4842	5158	5865
2 crude petroleum, gas	0	0	0	683	700	700	5429	6889	11044
3 shale oil	0	0	0	0	0	0	0	0	0
4 gasified coal	0	0	0	0	0	0	0	0	0
5 solvent-refined coal	0	0	0	0	0	0	0	0	0
6 ref'd petroleum products	0	0	0	2109	2353	2404	3186	3556	3632
7 natural gas utilities	0	0	0	3302	4201	8179	2176	2769	5390
8 coal combined cycle elec.	0	0	0	0	0	0	0	0	0
9 fossil electric utilities	0	0	0	1074	1204	1613	814	913	1223
10 nuclear elect. utilities	0	0	0	23	210	210	18	159	159
11 high-temp gas reactor	0	0	0	0	0	0	0	0	0
12 renewable elec. util's	0	0	0	13	35	35	10	27	27
13 ore-reduction feedstocks	0	0	0	215	281	408	215	281	408
14 chemical feedstocks	12	17	26	325	432	703	325	432	703
15 water transport	0	0	0	15	19	21	15	19	21
16 air transport	0	0	0	26	34	81	26	34	81
17 truck, bus transport	0	0	0	45	59	81	45	59	81
18 rail transport	0	0	0	17	21	31	17	21	31
19 auto transport	240	331	506	254	349	532	254	349	532
20 misc. thermal uses	0	0	0	1190	1541	2186	1190	1541	2186
21 water heat	113	119	127	166	189	227	166	189	227
22 space heat	486	515	550	787	909	1116	787	909	1116
23 air-conditioning	69	102	139	126	194	289	126	194	289
24 misc. elec. power uses	163	190	221	543	688	948	543	688	948
25 agriculture	827	1085	1285	8393	11011	13285	7312	9593	11574
26 mining	14	18	26	688	903	1324	1422	1864	2736
27 construction	11071	14527	21240	10562	13824	20201	13051	17083	24962
28 meat products	2260	2965	3225	2102	2758	3075	2747	3605	4020
29 food exc. meat products	6614	8679	9756	10603	13913	16907	9384	12314	14963
30 apparel and misc text. prod	455	597	842	302	395	564	1508	1975	2819
31 misc fabricated text. prod	2329	3056	4249	1162	1525	2134	2783	3651	5110
32 logging and misc. wood prod	885	1161	1659	1875	2454	3472	2412	3157	4467
33 misc paper prod and publ.	937	1230	1723	3257	4271	6023	2961	3882	5475
34 paper mills	37	48	67	431	565	799	732	959	1357
35 paperboard mills	1	1	1	248	325	447	391	513	706
36 paperboard containers	22	28	40	825	1081	1470	851	1116	1517
37 industrial org-inorg chem.	180	236	334	2644	3591	5317	2322	3154	4670
38 ag and misc chem.	1246	1635	2311	3026	4010	6252	2743	3634	5667
39 plastic and synthetic resins	14	19	26	1286	1690	2464	954	1254	1828
40 paving and asphalt	2	2	3	177	231	535	129	169	392
41 rubber and misc plastic prod	867	1138	1594	4163	5449	8365	2633	3447	5291
42 glass, stone, and clay prod	109	142	241	3586	4693	6803	1996	2612	3786
43 blast and basic steel prod	94	123	179	10475	13692	19930	5351	6995	10181
44 iron and steel found. and forging	12	16	24	1727	2257	3289	1304	1705	2484
45 other primary metal manufac.	0	0	0	657	861	1289	1566	2051	3072
46 nonfer. forge, cast, and rolling	58	77	113	3200	4187	6325	2129	2786	4207
47 fabricated metal containers	1005	1318	1983	6510	8519	12299	5683	7437	10737
48 industrial and farm machinery	3308	4341	6529	10506	13731	20313	7026	9183	13585

*Sectors 1-24 in trillions of Btu's; industries 25-67 in millions of 1967 dollars.

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TABLE B-3.1 (continued)

	final demand 1974	final demand 1985	final demand 2000	total production 1974	total production 1985	total production 2000	total consumption 1974	total consumption 1985	total consumption 2000
49 elec. equipment and components	3085	4048	6015	9635	12627	18590	6605	8657	12745
50 truck, bus, and auto manufac.	3403	4465	6970	6698	8787	13635	5751	7545	11708
51 misc transport. equipment	3093	4059	6105	2957	3878	5824	4004	5252	7887
52 misc manufac.	1382	1813	2632	1573	2063	3010	2274	2982	4351
53 railroads	406	533	739	1874	2430	3456	1874	2430	3456
54 misc transport. and communication	1989	2610	4069	3780	4939	7415	3780	4939	7415
55 motor freight transport.	669	878	1373	2387	3117	4907	2387	3117	4907
56 water transport.	224	294	326	566	731	812	566	731	812
57 air transport.	455	597	1498	527	692	1678	527	692	1678
58 wholesale trade	4269	5602	7427	7333	9611	13185	8107	10626	14577
59 retail trade	11029	14472	19188	12470	16351	21886	12563	16473	22049
60 finance and insurance	3329	4368	6984	5008	6558	10128	5795	7589	11721
61 real estate	9559	12543	20054	9487	12410	19117	14106	18451	28424
62 hotels, lodging, and amusements	1751	2298	3673	2895	3788	5760	3577	4681	7118
63 misc business and personal serv.	2201	2888	4618	3712	4859	7304	5015	6566	9869
64 advertising	22	29	47	1187	1554	2189	2215	2899	4086
65 auto repair	1072	1407	2249	1606	2105	3209	1879	2462	3754
66 medical and educational serv.	4630	6076	9714	4409	5785	9238	4754	6237	9960
67 nonprofit organizations	1298	1703	2723	1684	2209	3488	1493	1958	3092

*Sectors 1-24 in trillions of Btu's; industries 25-67 in millions of 1967 dollars.

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TABLE B-3.2
Baseline Data, 1974, and Scenario 4 Solutions to the ORBES Energy Demand Model, 1985 and 2000: Associated Transaction Matrices (trillions of Btu's)

	1	2	3	4	5	6	7	8	9	10	11	12
1	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3358.5	0.0	0.0	0.0
	58.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3647.2	0.0	0.0	0.0
	66.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4467.4	0.0	0.0	0.0
2	0.0	16.9	0.0	0.0	0.0	2109.5	3302.3	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	2557.6	4331.1	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	2612.8	8431.6	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	64.4	0.0	0.0	87.9	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	215.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	109.6	0.0	42.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	268.8	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	94.5	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	104.7	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	140.3	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.3	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.3	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0

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TABLE B-3.2 (continued)

	13	14	15	16	17	18	19	20	21	22	23	24
1	922.7 922.1 1093.2	7.9 10.5 14.1	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	478.5 464.6 224.5	0.0 0.0 0.0	65.2 55.8 0.0	0.0 0.0 0.0	0.0 0.0 0.0
2	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
6	0.0 0.0 0.0	238.8 313.3 477.9	72.5 89.2 94.7	128.0 159.9 370.4	225.4 279.9 366.7	82.9 102.4 138.9	1268.7 1395.6 1716.6	373.6 362.1 174.5	12.9 9.0 0.0	631.3 629.2 292.7	0.0 0.0 0.0	0.0 0.0 0.0
7	0.0 0.0 0.0	81.3 107.8 210.8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	788.3 1319.4 2751.6	198.0 236.3 306.2	950.6 1105.2 1852.6	6.2 0.0 0.0	0.0 0.0 0.0
8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
9	0.0 49.2 98.3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	100.4 84.1 41.6	32.5 29.0 29.6	17.1 13.9 0.0	43.8 59.7 90.3	525.6 572.0 822.7
10	0.0 8.6 12.8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	2.2 14.7 5.4	0.7 5.1 3.8	0.4 2.4 0.0	0.9 10.4 11.8	11.3 99.8 107.1
11	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
12	0.0 1.4 2.1	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	1.2 2.4 0.9	0.4 0.8 0.6	0.2 0.4 0.0	0.5 1.7 2.0	6.5 16.6 17.9

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TABLE B-3.3

Baseline Data, 1974, and Scenario 4 Solutions to the ORBES Energy Demand Model, 1985 and 2000: Associated Technical Coefficient Matrices (dimensioned Btu's input per Btu's output)

	1	2	3	4	5	6	7	8	9	10	11	12
1	0.00079	0.00000	0.00000	1.62000	1.69700	0.00000	0.00000	2.10872	3.12811	0.00000	0.00000	0.00000
	0.00498	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.02934	0.00000	0.00000	0.00000
	0.00498	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.76968	0.00000	0.00000	0.00000
2	0.00000	0.02470	0.00000	0.00000	0.00000	1.00040	1.00022	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	1.08696	1.03093	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	1.08696	1.03093	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.03053	0.00000	0.00000	0.08184	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.17857	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	0.00000	0.00000	0.00640	0.03319	0.00000	0.00000	0.03319	0.00000	0.03909	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.16667	0.00000	0.00000	0.00000
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.14837	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08800	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696	0.00000	0.00000	0.00000
10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08801	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696	0.00000	0.00000
11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.09000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08815
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08696

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TOP OF IMAGE AREA

TABLE B-3.3 (continued)

	13	14	15	16	17	18	19	20	21	22	23	24
1	4.30000	0.02428	0.00000	0.00000	0.00000	0.00000	0.00000	0.40212	0.00000	0.08283	0.00000	0.00000
	3.28723	0.02428	0.00000	0.00000	0.00000	0.00000	0.00000	0.30155	0.00000	0.06136	0.00000	0.00000
	2.67685	0.02000	0.00000	0.00000	0.00000	0.00000	0.00000	0.10273	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.73438	5.00000	5.00000	5.00000	5.00000	5.00000	0.31393	0.07789	0.80215	0.00000	0.00000
	0.00000	0.72585	4.76190	4.76190	4.76190	4.76190	4.00000	0.23501	0.04762	0.69233	0.00000	0.00000
	0.00000	0.68000	4.54545	4.54545	4.54545	4.54545	3.22581	0.07983	0.00000	0.26230	0.00000	0.00000
7	0.00000	0.24985	0.00000	0.00000	0.00000	0.00000	0.00000	0.66242	1.19153	1.20776	0.04906	0.00000
	0.00000	0.24986	0.00000	0.00000	0.00000	0.00000	0.00000	0.85631	1.24762	1.21608	0.00000	0.00000
	0.00000	0.30000	0.00000	0.00000	0.00000	0.00000	0.00000	1.25893	1.34921	1.65998	0.00000	0.00000
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08437	0.19538	0.02172	0.34611	0.96712
	0.17538	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.05458	0.15289	0.01533	0.30740	0.83091
	0.24068	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01902	0.13021	0.00000	0.31198	0.86809
10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00182	0.00422	0.00047	0.00747	0.02088
	0.03059	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00952	0.02667	0.00267	0.05362	0.14493
	0.03135	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00248	0.01696	0.00000	0.04063	0.11306
11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00105	0.00242	0.00027	0.00429	0.01200
	0.00510	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00159	0.00444	0.00045	0.00894	0.02416
	0.00522	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00041	0.00283	0.00000	0.00677	0.01884

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TABLE B-4.1
Scenario 2, 2a, and 4 Solutions to the ORBES Energy Demand Model, Year 2000*

	final demand			total production			total consumption		
	s2	s2a	s4	s2	s2a	s4	s2	s2a	s4
1 coal mining	0	0	0	20307	22322	13283	8967	9857	5865
2 crude petroleum, gas	0	0	0	703	709	700	5587	5641	11044
3 shale oil	0	0	0	0	0	0	0	0	0
4 gasified coal	0	0	0	0	0	0	0	0	0
5 solvent-refined coal	0	0	0	0	0	0	0	0	0
6 ref'd petroleum products	0	0	0	2318	2359	2404	3503	3565	3632
7 natural gas utilities	0	0	0	2975	2984	8179	1960	1967	5390
8 coal combined cycle elec.	0	0	0	0	0	0	0	0	0
9 fossil electric utilities	0	0	0	2232	2546	1613	1692	1742	1223
10 nuclear elect. utilities	0	0	0	210	210	210	159	144	159
11 high-temp gas reactor	0	0	0	0	0	0	0	0	0
12 renewable elec. util's	0	0	0	35	35	35	27	24	27
13 ore-reduction feedstocks	0	0	0	390	391	408	390	391	408
14 chemical feedstocks	26	26	26	704	706	703	704	706	703
15 water transport	0	0	0	21	21	21	21	21	21
16 air transport	0	0	0	49	49	81	49	49	81
17 truck, bus transport	0	0	0	80	80	81	80	80	81
18 rail transport	0	0	0	33	33	31	33	33	31
19 auto transport	506	506	506	532	532	532	532	532	532
20 misc. thermal uses	0	0	0	2149	2158	2186	2149	2158	2186
21 water heat	127	127	127	227	227	227	227	227	227
22 space heat	550	550	550	1117	1120	1116	1117	1120	1116
23 air-conditioning	139	139	139	289	290	289	289	290	289
24 misc. elec. power uses	221	221	221	940	943	948	940	943	948
25 agriculture	1290	1290	1285	13529	13533	13285	11787	11790	11574
26 mining	26	26	26	1292	1296	1324	2669	2677	2736
27 construction	21335	21335	21240	20338	20408	20201	25132	25218	24962
28 meat products	3239	3239	3225	3080	3081	3075	4026	4027	4020
29 food exc. meat products	9800	9800	9756	16963	16965	16907	15013	15014	14963
30 apparel and misc text. prod	846	846	842	569	570	564	2842	2847	2819
31 misc fabricated text. prod	4267	4267	4249	2136	2137	2134	5115	5117	5110
32 logging and misc. wood prod	1666	1666	1659	3450	3458	3472	4439	4449	4467
33 misc paper prod and publ.	1731	1731	1723	5983	5995	6023	5439	5450	5475
34 paper mills	67	67	67	794	796	799	1348	1351	1357
35 paperboard mills	1	1	1	436	437	447	689	690	706
36 paperboard containers	40	40	40	1425	1428	1470	1471	1473	1517
37 industrial org-inorg chem.	336	336	334	5304	5323	5317	4658	4675	4670
38 ag and misc chem.	2322	2322	2311	6301	6311	6252	5711	5720	5667
39 plastic and synthetic resins	26	26	26	2410	2415	2464	1787	1791	1828
40 paving and asphalt	3	3	3	542	544	535	397	398	392
41 rubber and misc plastic prod	1601	1601	1594	8576	8595	8365	5424	5436	5291
42 glass, stone, and clay prod	242	242	241	6734	6754	6803	3748	3759	3786
43 blast and basic steel prod	180	180	179	19074	19137	19930	9744	9776	10181
44 iron and steel found. and forging	24	24	24	3098	3108	3289	2340	2348	2484
45 other primary metal manufac.	0	0	0	1254	1257	1289	2987	2995	3072
46 nonfer. forge, cast, and rolling	113	113	113	6186	6202	6325	4115	4126	4207
47 fabricated metal containers	1992	1992	1983	12064	12095	12299	10532	10559	10737
48 industrial and farm machinery	6558	6558	6529	20294	20348	20313	13572	13608	13585

*Sectors 1-24 in trillions of Btu's; industries 25-67 in millions of 1967 dollars.

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TABLE B-4.1 (continued)

	final demand s2	final demand s2a	final demand s4	total production s2	total production s2a	total production s4	total consumption s2	total consumption s2a	total consumption s4
49 elec. equipment and components	6042	6042	6015	18563	18593	18590	12727	12747	12745
50 truck, bus, and auto manufac.	7001	7001	6970	13673	13677	13635	11740	11744	11708
51 misc transport. equipment	6132	6132	6105	5808	5810	5824	7866	7869	7887
52 misc manufac.	2643	2643	2632	3011	3013	3010	4352	4355	4351
53 railroads	786	786	739	3694	3746	3456	3694	3746	3456
54 misc transport. and communication	4087	4087	4069	7353	7370	7415	7353	7370	7415
55 motor freight transport.	1246	1246	1373	4440	4462	4907	4440	4462	4907
56 water transport.	327	327	326	818	827	812	818	827	812
57 air transport.	866	866	1498	1004	1004	1678	1004	1004	1678
58 wholesale trade	7460	7460	7427	13144	13166	13185	14532	14555	14577
59 retail trade	19273	19273	19188	21993	22013	21886	22156	22177	22049
60 finance and insurance	7015	7015	6984	10138	10158	10128	11732	11755	11721
61 real estate	20143	20143	20054	19190	19219	19117	28532	28575	28424
62 hotels, lodging, and amusements	3690	3690	3673	5753	5767	5760	7110	7127	7118
63 misc business and personal serv.	4639	4639	4618	7288	7305	7304	9847	9871	9869
64 advertising	47	47	47	2176	2184	2189	4060	4075	4086
65 auto repair	2259	2259	2249	3189	3195	3209	3731	3737	3754
66 medical and educational serv.	9757	9757	9714	9280	9281	9238	10005	10006	9960
67 nonprofit organizations	2735	2735	2723	3499	3500	3488	3102	3103	3092

*Sectors 1-24 in trillions of Btu's; industries 25-67 in millions of 1967 dollars.

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TABLE B-4.2
Scenario 2, 2a, and 4 Solutions to the ORBES Energy Demand Model, Year 2000: Associated Transaction Matrices (trillions of Btu's)

	1	2	3	4	5	6	7	8	9	10	11	12
1	101.1 111.2 66.1	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	6182.6 7052.4 4467.4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
2	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	2519.8 2564.0 2612.8	3066.8 3076.5 8431.6	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
6	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	372.0 424.4 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
7	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 268.8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
9	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	194.1 221.4 140.3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
10	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	18.3 18.3 18.3	0.0 0.0 0.0	0.0 0.0 0.0
11	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
12	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	3.0 3.0 3.0

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TABLE B-4.2 (continued)

	13	14	15	16	17	18	19	20	21	22	23	24
1	1044.2 1047.6 1093.2	70.4 70.6 14.1	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	1568.7 1575.0 224.5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
2	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
6	0.0 0.0 0.0	478.5 480.0 477.9	87.4 88.4 94.7	203.1 203.2 370.4	332.1 334.7 366.7	136.1 138.1 138.9	1267.1 1267.2 1716.6	289.4 290.6 174.5	0.0 0.0 0.0	337.2 338.2 292.7	0.0 0.0 0.0	0.0 0.0 0.0
7	0.0 0.0 0.0	154.8 155.3 210.8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	759.0 762.1 2751.6	120.2 120.4 306.2	926.4 929.0 1852.6	0.0 0.0 0.0	0.0 0.0 0.0
8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
9	97.5 99.0 98.3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	175.8 178.7 41.6	126.7 128.5 29.6	161.2 163.6 0.0	89.4 90.7 90.3	847.3 860.6 822.7
10	9.2 8.2 12.8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	16.5 14.7 5.4	11.9 10.6 3.8	15.2 13.5 0.0	8.4 7.5 11.8	79.7 71.0 107.1
11	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
12	1.5 1.4 2.1	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	2.8 2.5 0.9	2.0 1.8 0.6	2.5 2.2 0.0	1.4 1.2 2.0	13.3 11.8 17.9

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TABLE B-4.3

Scenario 2, 2a, and 4 Solutions to the ORBES Energy Demand Model, Year 2000: Associated Technical Coefficient Matrices (dimensioned Btu's input per Btu's output)

	1	2	3	4	5	6	7	8	9	10	11	12
1	0.00498 0.00498 0.00498	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	2.76968 2.76968 2.76968	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
2	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	1.08696 1.08696 1.08696	1.03093 1.03093 1.03093	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
3	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
4	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
5	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
6	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.16667 0.16667 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
7	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.16667	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
8	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
9	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.08696 0.08696 0.08696	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
10	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.08696 0.08696 0.08696	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
11	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
12	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.08696 0.08696 0.08696

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TABLE B-4.3 (continued)

	13	14	15	16	17	18	19	20	21	22	23	24
1	2.67685	0.10000	0.00000	0.00000	0.00000	0.00000	0.00000	0.72988	0.00000	0.00000	0.00000	0.00000
	2.67685	0.10000	0.00000	0.00000	0.00000	0.00000	0.00000	0.72988	0.00000	0.00000	0.00000	0.00000
	2.67685	0.02000	0.00000	0.00000	0.00000	0.00000	0.00000	0.10273	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.68000	4.16667	4.16667	4.16667	4.16667	2.38095	0.13465	0.00000	0.30197	0.00000	0.00000
	0.00000	0.68000	4.16667	4.16667	4.16667	4.16667	2.38095	0.13465	0.00000	0.30197	0.00000	0.00000
	0.00000	0.68000	4.54545	4.54545	4.54545	4.54545	3.22581	0.07983	0.00000	0.26230	0.00000	0.00000
7	0.00000	0.22000	0.00000	0.00000	0.00000	0.00000	0.00000	0.35316	0.52910	0.82955	0.00000	0.00000
	0.00000	0.22000	0.00000	0.00000	0.00000	0.00000	0.00000	0.35316	0.52910	0.82955	0.00000	0.00000
	0.00000	0.30000	0.00000	0.00000	0.00000	0.00000	0.00000	1.25893	1.34921	1.65998	0.00000	0.00000
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	0.24983	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08182	0.55782	0.14432	0.30913	0.90110
	0.25292	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08283	0.56471	0.14611	0.31294	0.91223
	0.24068	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01902	0.13021	0.00000	0.31198	0.86809
10	0.02350	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00770	0.05247	0.01358	0.02908	0.08476
	0.02086	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00683	0.04657	0.01205	0.02581	0.07523
	0.03135	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00248	0.01696	0.00000	0.04063	0.11306
11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12	0.00392	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00128	0.00875	0.00226	0.00485	0.01413
	0.00348	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00114	0.00776	0.00201	0.00430	0.01254
	0.00522	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00041	0.00283	0.00000	0.00677	0.01884

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TABLE B-5.1
Scenario 3, 5, and 5a Solutions to the ORBES Energy Demand Model, Year 2000*

	final demand			total production			total consumption		
	s3	s5	s5a	s3	s5	s5a	s3	s5	s5a
1 coal mining	0	0	0	17137	18601	23422	7567	8214	10343
2 crude petroleum, gas	0	0	0	612	650	805	4869	5167	6397
3 shale oil	0	0	0	0	0	0	0	0	0
4 gasified coal	0	0	0	0	0	0	0	0	0
5 solvent-refined coal	0	0	0	0	0	0	0	0	0
6 ref'd petroleum products	0	0	0	2192	2128	2707	3312	3215	4090
7 natural gas utilities	0	0	0	2412	2769	3351	1589	1825	2208
8 central station elec.	0	0	0	2216	2302	2797	1680	1745	2120
9 fossil electric utilities	0	0	0	1884	2057	2552	2216	2057	2552
10	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0
13 ore-reduction feedstocks	0	0	0	388	351	461	388	351	461
14 chemical feedstocks	26	24	31	701	637	826	701	637	826
15 water transport	0	0	0	21	19	24	21	19	24
16 air transport	0	0	0	49	44	57	49	44	57
17 truck, bus transport	0	0	0	79	73	92	79	73	92
18 rail transport	0	0	0	32	30	38	32	30	38
19 auto transport	506	465	608	532	489	638	532	489	638
20 misc. thermal uses	0	0	0	1583	1947	2519	2132	1947	2519
21 water heat	127	127	127	151	218	244	227	218	244
22 space heat	550	550	550	960	1063	1215	1111	1063	1215
23 air-conditioning	86	139	139	200	275	315	199	275	315
24 misc. elec. power uses	221	221	221	920	871	1067	935	871	1067
25 agriculture	1290	1202	1443	13522	12622	15112	11781	10997	13166
26 mining	26	24	31	1286	1165	1523	2656	2407	3145
27 construction	21335	19225	25175	20251	18337	23984	24992	22660	29638
28 meat products	3239	3060	3544	3080	2901	3389	4026	3792	4430
29 food exc. meat products	9800	9209	10814	16960	15907	18787	15010	14078	16627
30 apparel and misc text. prod	846	766	989	568	516	666	2834	2575	3324
31 misc fabricated text. prod	4267	3876	4972	2135	1939	2492	5112	4643	5967
32 logging and misc. wood prod	1666	1507	1954	3439	3118	4053	4425	4012	5215
33 misc paper prod and publ.	1731	1570	2020	5967	5433	6978	5422	4939	6343
34 paper mills	67	61	79	792	721	927	1343	1223	1572
35 paperboard mills	1	1	2	435	398	505	686	628	798
36 paperboard containers	40	36	47	1422	1302	1648	1467	1343	1700
37 industrial org-inorg chem.	336	304	393	5275	4832	6160	4520	4244	5411
38 ag and misc chem.	2322	2103	2716	6286	5724	7346	5651	5188	6658
39 plastic and synthetic resins	26	24	31	2402	2182	2823	1782	1619	2094
40 paving and asphalt	3	3	4	540	489	640	395	358	468
41 rubber and misc plastic prod	1601	1453	1869	8551	7756	10068	5407	4905	6368
42 glass, stone, and clay prod	242	213	297	6708	6075	7939	3733	3381	4418
43 blast and basic steel prod	180	162	212	18986	17170	22554	9698	8771	11522
44 iron and steel found. and forging	24	22	28	3084	2785	3672	2330	2104	2774
45 other primary metal manufac.	0	0	0	1249	1128	1483	2976	2689	3533
46 nonfer. forge, cast, and rolling	113	102	133	6165	5565	7322	4101	3702	4871
47 fabricated metal containers	1992	1786	2367	12020	10874	14236	10490	9493	12428
48 industrial and farm machinery	6558	5883	7795	20216	18239	24056	13517	12198	16088

*Sectors 1-24 in trillions of Btu's; industries 25-67 in millions of 1967 dollars.

TABLE B-5.1 (continued)

	final demand			total production			total consumption*		
	s3	s5	s5a	s3	s5	s5a	s3	s5	s5a
49 elec. equipment and components	6042	5430	7159	18528	16690	21987	12694	11442	15074
50 truck, bus, and auto manufac.	7001	6243	8400	13668	12203	16384	11735	10478	14068
51 misc transport. equipment	6132	5500	7288	5806	5213	6897	7862	7060	9341
52 misc manufac.	2643	2385	3114	3008	2715	3551	4347	3924	5133
53 railroads	786	708	928	3633	3346	4327	3627	3346	4327
54 misc transport. and communication	4087	3645	4902	7328	6601	8734	7323	6601	8734
55 motor freight transport.	1246	1129	1457	4414	4033	5178	4413	4033	5178
56 water transport.	327	308	360	807	758	927	806	758	927
57 air transport.	866	782	1019	1003	906	1181	1003	906	1181
58 wholesale trade	7460	6828	8586	13116	11977	15246	14495	13241	16855
59 retail trade	19273	17640	22182	21966	20102	25374	22121	20251	25563
60 finance and insurance	7015	6231	8468	10108	9054	12138	11688	10478	14047
61 real estate	20143	17893	24317	19142	17144	22967	28458	25491	34149
62 hotels, lodging, and amusements	3690	3278	4454	5733	5146	6873	7080	6359	8493
63 misc business and personal serv.	4639	4120	5600	7264	6538	8667	9804	8834	11711
64 advertising	47	42	57	2165	1980	2531	4034	3694	4723
65 auto repair	2259	2007	2727	3181	2854	3807	3719	3339	4453
66 medical and educational serv.	9757	8567	11779	9279	8245	11200	10003	8889	12075
67 nonprofit organizations	2735	2430	3302	3497	3114	4212	3100	2761	3733

*Sectors 1-24 in trillions of Btu's; industries 25-67 in millions of 1967 dollars.

TABLE B-5.2
Scenario 3, 5, and 5a Solutions to the ORBES Energy Demand Model, Year 2000: Associated Transaction Matrices (trillions of Btu's)

	1	2	3	4	5	6	7	8	9	10	11	12
1	85.3 92.6 116.6	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	5216.8 5696.6 7069.4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
2	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	2382.5 2312.8 2942.1	2486.3 2854.6 3454.5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
6	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	313.9 342.8 425.4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
7	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	192.7 200.2 243.3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
9	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	2215.7 2301.8 2797.4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
10	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
11	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
12	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0

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TABLE B-5.2 (continued)

	13	14	15	16	17	18	19	20	21	22	23	24
1	1039.4 939.8 1235.1	70.1 63.7 82.6	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	1155.7 1421.0 1838.9	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
2	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
6	0.0 0.0 0.0	476.5 433.5 561.4	86.2 80.9 99.1	203.0 183.3 239.0	328.6 304.5 381.6	133.9 123.3 159.5	1267.0 1163.7 1518.1	213.2 262.2 339.3	0.0 0.0 0.0	289.8 321.0 366.8	0.0 0.0 0.0	0.0 0.0 0.0
7	0.0 0.0 0.0	154.2 140.2 181.6	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	559.2 687.6 889.8	80.0 115.2 129.2	796.1 881.8 1007.8	0.0 0.0 0.0	0.0 0.0 0.0
8	107.7 97.3 127.9	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	143.8 176.8 228.8	93.6 134.8 151.2	153.7 170.3 194.6	68.5 94.3 108.2	919.6 871.1 1066.5
9	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
10	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
11	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
12	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0

TABLE B-5.3

Scenario 3, 5, and 5a Solutions to the ORBES Energy Demand Model, Year 2000: Associated Technical Coefficient Matrices (dimensioned Btu's input per Btu's output)

	1	2	3	4	5	6	7	8	9	10	11	12
1	0.00498 0.00498 0.00498	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	2.76968 2.76968 2.76968	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
2	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	1.08696 1.08696 1.08696	1.03093 1.03093 1.03093	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
3	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
4	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
5	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
6	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.16667 0.16667 0.16667	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
7	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
8	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.08696 0.08696 0.08696	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
9	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	1.00000 1.00000 1.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
10	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
11	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
12	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000

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TABLE B-5.3 (continued)

	13	14	15	16	17	18	19	20	21	22	23	24
1	2.67685 2.67685 2.67685	0.10000 0.10000 0.10000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.72988 0.72988 0.72988	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
2	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
3	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
4	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
5	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
6	0.00000 0.00000 0.00000	0.68000 0.68000 0.68000	4.16667 4.16667 4.16667	4.16667 4.16667 4.16667	4.16667 4.16667 4.16667	4.16667 4.16667 4.16667	2.38095 2.38095 2.38095	0.13465 0.13465 0.13465	0.00000 0.00000 0.00000	0.30197 0.30197 0.30197	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
7	0.00000 0.00000 0.00000	0.22000 0.22000 0.22000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.35316 0.35316 0.35316	0.52910 0.52910 0.52910	0.82955 0.82955 0.82955	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
8	0.27725 0.27725 0.27725	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.09080 0.09080 0.09080	0.61905 0.61905 0.61905	0.16017 0.16017 0.16017	0.34305 0.34305 0.34305	1.00000 1.00000 1.00000
9	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
10	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
11	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
12	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
DROPPED HEAD BEGIN SECTIONS HERE
CENTER OF PAGE
TOP OF IMAGE AREA
BEGIN LAST LINE OF TEXT
3/8"
PAGE NUMBER
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
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TABLE B-6.1
Scenario 3, 5, and 6 Solutions to the ORBES Energy Demand Model, Year 2000*

	final demand			total production			total consumption		
	s3	s5	s6	s3	s5	s6	s3	s5	s6
1 coal mining	0	0	0	17137	18601	11543	7567	8214	5097
2 crude petroleum, gas	0	0	0	612	650	645	4869	5167	5129
3 shale oil	0	0	0	0	0	0	0	0	0
4 gasified coal	0	0	0	0	0	0	0	0	0
5 solvent-refined coal	0	0	0	0	0	0	0	0	0
6 ref'd petroleum products	0	0	0	2192	2128	1831	3312	3215	2767
7 natural gas utilities	0	0	0	2412	2769	3044	1589	1825	2006
8 central station elec.	0	0	0	2216	2302	1403	1680	1745	1063
9 fossil electric utilities	0	0	0	1884	2057	1018	2216	2057	1403
10	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0
13 ore-reduction feedstocks	0	0	0	388	351	361	388	351	361
14 chemical feedstocks	26	24	14	701	637	679	701	637	679
15 water transport	0	0	0	21	19	20	21	19	20
16 air transport	0	0	0	49	44	48	49	44	48
17 truck, bus transport	0	0	0	79	73	75	79	73	75
18 rail transport	0	0	0	32	30	32	32	30	32
19 auto transport	506	465	271	532	489	297	532	489	297
20 misc. thermal uses	0	0	0	1583	1947	1716	2132	1947	2039
21 water heat	127	127	127	151	218	226	227	218	226
22 space heat	550	550	550	960	1063	1062	1111	1063	1102
23 air-conditioning	86	139	78	200	275	185	199	275	185
24 misc. elec. power uses	221	221	148	920	871	700	935	871	769
25 agriculture	1290	1202	1291	13522	12622	13696	11781	10997	11932
26 mining	26	24	26	1286	1165	1226	2656	2407	2533
27 construction	21335	19225	21346	20251	18337	20072	24992	22660	24803
28 meat products	3239	3060	3241	3080	2901	3080	4026	3792	4025
29 food exc. meat products	9800	9209	9805	16960	15907	16959	15010	14078	15010
30 apparel and misc text. prod	846	766	846	568	516	565	2834	2575	2819
31 misc fabricated text. prod	4267	3876	4270	2135	1939	2126	5112	4643	5090
32 logging and misc. wood prod	1666	1507	1667	3439	3118	3367	4425	4012	4332
33 misc paper prod and publ.	1731	1570	1732	5967	5433	5862	5422	4939	5329
34 paper mills	67	61	68	792	721	777	1343	1223	1318
35 paperboard mills	1	1	1	435	398	417	686	628	659
36 paperboard containers	40	36	40	1422	1302	1356	1467	1343	1399
37 industrial org-inorg chem.	336	304	336	5275	4832	5133	4520	4244	4508
38 ag and misc chem.	2322	2103	2323	6286	5724	6255	5651	5188	5670
39 plastic and synthetic resins	26	24	26	2402	2182	2305	1782	1619	1710
40 paving and asphalt	3	3	3	540	489	539	395	358	395
41 rubber and misc plastic prod	1601	1453	1602	8551	7756	8613	5407	4905	5448
42 glass, stone, and clay prod	242	213	243	6708	6075	6523	3733	3381	3630
43 blast and basic steel prod	180	162	180	18986	17170	17707	9698	8771	9046
44 iron and steel found. and forging	24	22	24	3084	2785	2819	2330	2104	2130
45 other primary metal manufac.	0	0	0	1249	1128	1189	2976	2689	2834
46 nonfer. forge, cast, and rolling	113	102	113	6165	5565	5919	4101	3702	3937
47 fabricated metal containers	1992	1786	1993	12020	10874	11578	10490	9493	10108
48 industrial and farm machinery	6558	5883	6562	20216	18239	19818	13517	12198	13254

*Sectors 1-24 in trillions of Btu's; industries 25-67 in millions of 1967 dollars.

BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
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EPA-287 (Cin.)
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TABLE B-6.1 (continued)

	final demand			total production			total consumption		
	s3	s5	s6	s3	s5	s6	s3	s5	s6
49 elec. equipment and components	6042	5430	6045	18528	16690	18304	12694	11442	12549
50 truck, bus, and auto manufac.	7001	6243	7004	13668	12203	13633	11735	10478	11706
51 misc transport. equipment	6132	5500	6135	5806	5213	5792	7862	7060	7844
52 misc manufac.	2643	2385	2645	3008	2715	2989	4347	3924	4321
53 railroads	786	708	823	3633	3346	3594	3627	3346	3594
54 misc transport. and communication	4087	3645	4089	7328	6601	7228	7323	6601	7228
55 motor freight transport.	1246	1129	1127	4414	4033	3903	4413	4033	3903
56 water transport.	327	308	327	807	758	772	806	758	772
57 air transport.	866	782	861	1003	906	995	1003	906	995
58 wholesale trade	7460	6828	7464	13116	11977	12950	14495	13241	14316
59 retail trade	19273	17640	19283	21966	20102	21902	22121	20251	22065
60 finance and insurance	7015	6231	7018	10108	9054	10016	11688	10478	11592
61 real estate	20143	17893	20154	19142	17144	19025	28458	25491	28287
62 hotels, lodging, and amusements	3690	3278	3692	5733	5146	5666	7080	6359	7002
63 misc business and personal serv.	4639	4120	4641	7264	6538	7157	9804	8834	9671
64 advertising	47	42	47	2165	1980	2124	4034	3694	3964
65 auto repair	2259	2007	2260	3181	2854	3124	3719	3339	3655
66 medical and educational serv.	9757	8667	9763	9279	8245	9282	10003	8889	10007
67 nonprofit organizations	2735	2430	2737	3497	3114	3492	3100	2761	3096

*Sectors 1-24 in trillions of Btu's; industries 25-67 in millions of 1967 dollars.

EPA-287 (Cin.)
(4-76)

TABLE B-6.2

Scenario 3, 5, and 6 Solutions to the ORBES Energy Demand Model, Year 2000:
Associated Transaction Matrices (trillions of Btu's)

	1	2	3	4	5	6	7	8	9	10	11	12
1	85.3 92.6 57.5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	5216.8 5696.6 2819.5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
2	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	2382.5 2312.8 1990.2	2486.3 2854.6 3138.6	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
6	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	313.9 342.8 169.7	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
7	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
8	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	192.7 200.2 122.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
9	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	2215.7 2301.8 1403.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
10	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
11	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
12	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0

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TABLE B-6.2 (continued)

	13	14	15	16	17	18	19	20	21	22	23	24
1	1039.4 939.8 967.0	70.1 63.7 68.6	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	1155.7 1421.0 7[illegible]1.1	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
2	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
3	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
4	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
5	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
6	0.0 0.0 0.0	476.5 433.5 354.8	86.2 80.9 99.0	203.0 183.3 108.7	328.6 304.5 226.3	133.9 123.3 144.6	1267.0 1163.7 541.6	213.2 262.2 411.2	0.0 0.0 39.7	289.8 321.0 396.0	0.0 0.0 0.0	0.0 0.0 0.0
7	0.0 0.0 0.0	154.2 140.2 255.7	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	559.2 687.6 754.7	80.0 115.2 258.9	796.1 881.8 737.2	0.0 0.0 0.0	0.0 0.0 0.0
8	107.7 97.3 100.2	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	143.8 176.8 0.0	93.6 134.8 0.0	153.7 170.3 91.6	68.5 94.3 49.8	919.6 871.1 700.0
9	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
10	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
11	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
12	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0

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TABLE B-6.3

Scenario 3, 5, and 6 Solutions to the CRBES Energy Demand Model, Year 2000: Associated Technical Coefficient Matrices (dimensioned Btu's input per Btu's output)

	1	2	3	4	5	6	7	8	9	10	11	12
1	0.00498 0.00498 0.00498	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	2.76968 2.76968 2.76968	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
2	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	1.08696 1.08696 1.08696	1.03093 1.03093 1.03093	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
3	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
4	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
5	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
6	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.16667 0.16667 0.16667	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
7	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
8	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.08696 0.08696 0.08696	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
9	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	1.00000 1.00000 1.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
10	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
11	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000
12	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000	0.00000 0.00000 0.00000

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TABLE B-6.3 (continued)

	13	14	15	16	17	18	19	20	21	22	23	24
1	2.67685	0.10000	0.00000	0.00000	0.00000	0.00000	0.00000	0.72988	0.00000	0.00000	0.00000	0.00000
	2.67685	0.10000	0.00000	0.00000	0.00000	0.00000	0.00000	0.72988	0.00000	0.00000	0.00000	0.00000
	2.57685	0.10104	0.00000	0.00000	0.00000	0.00000	0.00000	0.43192	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.68000	4.16667	4.16667	4.16667	4.16667	2.38095	0.13465	0.00000	0.30197	0.00000	0.00000
	0.00000	0.68000	4.16667	4.16667	4.16667	4.16667	2.38095	0.13465	0.00000	0.30197	0.00000	0.00000
	0.00000	0.52247	5.00000	2.25000	3.00000	4.55000	1.82432	0.23965	0.17593	0.37279	0.00000	0.00000
7	0.00000	0.22000	0.00000	0.00000	0.00000	0.00000	0.00000	0.35316	0.52910	0.82955	0.00000	0.00000
	0.00000	0.22000	0.00000	0.00000	0.00000	0.00000	0.00000	0.35316	0.52910	0.82955	0.00000	0.00000
	0.00000	0.37649	0.00000	0.00000	0.00000	0.00000	0.00000	0.43981	1.14683	0.69390	0.00000	0.00000
8	0.27725	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.09080	0.61905	0.16017	0.34305	1.00000
	0.27725	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.09080	0.61905	0.16017	0.34305	1.00000
	0.27725	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08621	0.26954	1.00000
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
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APPENDIX C

TABLE C-1

Baseline Energy End Use, 1974
(in trillion Btu's)

		Coal	Crude Oil and Gas	Refined Petroleum	Natural Gas	Electricity
1	Residential	40.6	0.0	407.7	727.8	221.5
2	Commercial	23.0	0.0	179.3	321.5	118.0
3	Industrial	1344.1	0.0	522.0	801.8	366.2
4	Electric Power	3359.1	0.0	94.1	51.8	102.3
5	Energy Conversion	56.1	5428.7	103.2	190.4	18.1
6	Agriculture	2.2	0.0	21.5	33.8	5.4
7	Mining	8.9	0.0	7.0	14.7	7.9
8	Construction	7.4	0.0	74.2	34.1	2.1
9	Water transport	0.0	0.0	72.5	0.0	0.0
10	Air transport	0.0	0.0	128.0	0.0	0.0
11	Truck transport	0.0	0.0	225.4	0.0	0.0
12	Rail transport	0.0	0.0	82.9	0.0	0.0
13	Auto transport	0.0	0.0	1268.7	0.0	0.0
14	Total Consumption	4841.5	5428.7	3186.5	2175.9	841.5

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TABLE C-2

Energy End Use, 1985, Scenario 1
(in trillion Btu's)

		Coal	Crude Oil and Gas	Refined Petro- leum	Natural Gas	Elec- tricity
1	Residential	15.1	0.0	314.5	690.6	307.3
2	Commercial	17.3	0.0	170.2	377.0	183.0
3	Industrial	1628.3	0.0	583.7	903.7	550.1
4	Electric Power	4908.1	0.0	290.7	14.9	167.8
5	Energy Conversion	139.3	5738.2	32.1	71.1	19.6
6	Agriculture	1.0	0.0	20.4	40.8	9.1
7	Mining	15.0	0.0	7.3	16.2	10.5
8	Construction	11.6	0.0	95.4	42.4	3.1
9	Water transport	0.0	0.0	86.0	0.0	0.0
10	Air transport	0.0	0.0	152.7	0.0	0.0
11	Truck transport	0.0	0.0	270.7	0.0	0.0
12	Rail transport	0.0	0.0	100.3	0.0	0.0
13	Auto transport	0.0	0.0	1163.1	0.0	0.0
14	Total Consumption	6735.6	5738.2	3287.2	2156.7	1250.4

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TABLE C-3

Energy End Use, 2000, Scenario 1
(in trillion Btu's)

		Coal	Crude Oil and Gas	Refined Petroleum	Natural Gas	Electricity
1	Residential	2.6	0.0	183.7	529.6	436.3
2	Commercial	19.9	0.0	129.9	390.1	327.1
3	Industrial	2526.7	0.0	620.2	875.4	827.7
4	Electric Power	6312.8	0.0	377.3	14.7	228.8
5	Energy Conversion	202.7	5587.5	18.8	49.1	22.1
6	Agriculture	0.2	0.0	13.6	36.5	15.8
7	Mining	31.1	0.0	5.6	14.8	15.0
8	Construction	36.6	0.0	128.2	50.6	5.3
9	Water transport	0.0	0.0	87.5	0.0	0.0
10	Air transport	0.0	0.0	203.1	0.0	0.0
11	Truck transport	0.0	0.0	332.2	0.0	0.0
12	Rail transport	0.0	0.0	136.2	0.0	0.0
13	Auto transport	0.0	0.0	1267.1	0.0	0.0
14	Total Consumption	9132.6	5587.5	3503.6	1960.8	1878.1

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TABLE C-4

Energy End Use, 1985, Scenario 2
(in trillion Btu's)

		Coal	Crude Oil and Gas	Refined Petroleum	Natural Gas	Electricity
1	Residential	15.1	0.0	314.5	690.6	307.3
2	Commercial	17.1	0.0	170.2	376.9	183.0
3	Industrial	1613.7	0.0	583.5	903.5	549.9
4	Electric Power	4807.9	0.0	290.7	14.9	167.8
5	Energy Conversion	136.6	5737.4	32.1	71.0	19.6
6	Agriculture	1.0	0.0	20.4	40.8	9.1
7	Mining	14.7	0.0	7.3	16.2	10.5
8	Construction	11.4	0.0	95.4	42.4	3.1
9	Water transport	0.0	0.0	86.0	0.0	0.0
10	Air transport	0.0	0.0	152.7	0.0	0.0
11	Truck transport	0.0	0.0	270.5	0.0	0.0
12	Rail transport	0.0	0.0	100.3	0.0	0.0
13	Auto transport	0.0	0.0	1163.1	0.0	0.0
14	Total Consumption	6617.4	5737.4	3286.8	2156.4	1250.1

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TABLE C-5

Energy End Use, 2000, Scenario 2
(in trillion Btu's)

		Coal	Crude Oil and Gas	Refined Petroleum	Natural Gas	Electricity
1	Residential	2.6	0.0	183.7	529.6	436.3
2	Commercial	19.5	0.0	129.9	390.0	327.1
3	Industrial	2496.7	0.0	620.1	875.2	827.5
4	Electric Power	6182.6	0.0	377.3	14.7	228.7
5	Energy Conversion	198.7	5586.6	18.8	49.0	22.1
6	Agriculture	0.2	0.0	13.6	36.5	15.8
7	Mining	30.5	0.0	5.6	14.8	15.0
8	Construction	36.3	0.0	128.2	50.6	5.3
9	Water transport	0.0	0.0	87.4	0.0	0.0
10	Air transport	0.0	0.0	203.1	0.0	0.0
11	Truck transport	0.0	0.0	332.1	0.0	0.0
12	Rail transport	0.0	0.0	136.1	0.0	0.0
13	Auto transport	0.0	0.0	1267.1	0.0	0.0
14	Total Consumption	8966.9	5586.6	3503.1	1960.5	1877.7

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TABLE C-6

Energy End Use, 2000, Scenario 2a
(in trillion Btu's)

		Coal	Crude Oil and Gas	Refined Petroleum	Natural Gas	Electricity
1	Residential	2.6	0.0	183.7	529.6	436.3
2	Commercial	19.6	0.0	130.2	390.7	327.5
3	Industrial	2504.0	0.0	621.8	877.5	829.7
4	Electric Power	7052.4	0.0	430.3	16.6	257.7
5	Energy Conversion	211.1	5640.5	19.2	50.2	22.7
6	Agriculture	0.2	0.0	13.6	36.5	15.8
7	Mining	30.6	0.0	5.6	14.8	15.1
8	Construction	36.4	0.0	128.7	50.8	5.3
9	Water transport	0.0	0.0	88.4	0.0	0.0
10	Air transport	0.0	0.0	203.2	0.0	0.0
11	Truck transport	0.0	0.0	334.7	0.0	0.0
12	Rail transport	0.0	0.0	138.1	0.0	0.0
13	Auto transport	0.0	0.0	1267.2	0.0	0.0
14	Total Consumption	9856.8	5640.5	3564.5	1966.7	1910.1

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TABLE C-7

Energy End Use, 2000, Scenario 3
(in trillion Btu's)

		Coal	Crude Oil and Gas	Refined Petroleum	Natural Gas	Electricity
1	Residential	2.6	0.0	160.8	444.3	375.7
2	Commercial	14.7	0.0	112.1	325.6	288.0
3	Industrial	2126.3	0.0	546.8	685.1	763.7
4	Electric Power	5216.8	0.0	317.8	10.8	203.3
5	Energy Conversion	152.8	4868.8	13.1	33.9	17.0
6	Agriculture	0.2	0.0	11.9	31.2	14.0
7	Mining	22.5	0.0	4.2	10.9	13.8
8	Construction	31.5	0.0	126.8	47.7	4.0
9	Water transport	0.0	0.0	86.2	0.0	0.0
10	Air transport	0.0	0.0	203.0	0.0	0.0
11	Truck transport	0.0	0.0	328.6	0.0	0.0
12	Rail transport	0.0	0.0	133.9	0.0	0.0
13	Auto transport	0.0	0.0	1267.0	0.0	0.0
14	Total Consumption	7567.4	4868.8	3312.2	1589.4	1679.5

TABLE C-8

Energy End Use, 1985, Scenario 4
(in trillion Btu's)

		Coal	Crude Oil and Gas	Refined Petroleum	Natural Gas	Electricity
1	Residential	32.0	0.0	374.3	779.0	259.0
2	Commercial	22.5	0.0	201.3	428.0	156.8
3	Industrial	1339.5	0.0	572.4	1316.0	514.1
4	Electric Power	3647.8	0.0	222.0	12.9	132.1
5	Energy Conversion	97.6	6888.7	32.6	115.0	17.4
6	Agriculture	2.1	0.0	24.4	44.8	6.9
7	Mining	8.8	0.0	6.9	25.0	9.8
8	Construction	8.1	0.0	94.7	47.9	2.3
9	Water transport	0.0	0.0	89.2	0.0	0.0
10	Air transport	0.0	0.0	159.9	0.0	0.0
11	Truck transport	0.0	0.0	279.9	0.0	0.0
12	Rail transport	0.0	0.0	102.4	0.0	0.0
13	Auto transport	0.0	0.0	1395.6	0.0	0.0
14	Total Consumption	5158.4	6888.7	3555.6	2768.7	1098.3

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TABLE C-9

Energy End Use, 2000, Scenario 4
(in trillion Btu's)

		Coal	Crude Oil and Gas	Refined Petroleum	Natural Gas	Electricity
1	Residential	0.5	0.0	161.8	1093.2	290.6
2	Commercial	2.8	0.0	113.9	820.4	221.2
3	Industrial	1304.1	0.0	512.6	2792.7	692.0
4	Electric Power	4467.4	0.0	3.4	291.1	169.2
5	Energy Conversion	79.9	11044.4	12.2	176.8	13.4
6	Agriculture	0.0	0.0	11.8	72.5	7.4
7	Mining	4.4	0.0	3.4	53.9	12.4
8	Construction	6.2	0.0	126.0	89.3	2.2
9	Water transport	0.0	0.0	94.7	0.0	0.0
10	Air transport	0.0	0.0	370.4	0.0	0.0
11	Truck transport	0.0	0.0	366.7	0.0	0.0
12	Rail transport	0.0	0.0	138.9	0.0	0.0
13	Auto transport	0.0	0.0	1716.6	0.0	0.0
14	Total Consumption	5865.4	11044.4	3632.4	5390.0	1408.4

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TABLE C-10

Energy End Use, 2000, Scenario 5
(in trillion Btu's)

		Coal	Crude Oil and Gas	Refined Petroleum	Natural Gas	Electricity
1	Residential	2.4	0.0	182.3	529.2	436.3
2	Commercial	17.7	0.0	117.2	351.8	294.8
3	Industrial	2254.6	0.0	561.7	792.2	747.8
4	Electric Power	5696.6	0.0	347.7	13.7	212.5
5	Energy Conversion	182.2	5167.4	17.3	45.0	20.3
6	Agriculture	0.2	0.0	12.7	34.1	14.7
7	Mining	27.5	0.0	5.1	13.3	13.6
8	Construction	32.7	0.0	115.6	45.7	4.7
9	Water transport	0.0	0.0	80.9	0.0	0.0
10	Air transport	0.0	0.0	183.3	0.0	0.0
11	Truck transport	0.0	0.0	304.5	0.0	0.0
12	Rail transport	0.0	0.0	123.3	0.0	0.0
13	Auto transport	0.0	0.0	1163.7	0.0	0.0
14	Total Consumption	8213.8	5167.4	3215.3	1824.9	1744.8

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TABLE C-11

Energy End Use, 2000, Scenario 5a
(in trillion Btu's)

		Coal	Crude Oil and Gas	Refined Petroleum	Natural Gas	Electricity
1	Residential	3.1	0.0	187.2	530.7	436.3
2	Commercial	22.8	0.0	153.3	459.9	386.1
3	Industrial	2938.2	0.0	726.3	1026.2	972.7
4	Electric Power	7069.4	0.0	431.3	16.6	258.3
5	Energy Conversion	230.3	6396.6	21.9	57.0	25.6
6	Agriculture	0.2	0.0	15.2	40.8	17.6
7	Mining	35.9	0.0	6.6	17.4	17.7
8	Construction	42.8	0.0	151.2	59.7	6.2
9	Water transport	0.0	0.0	99.1	0.0	0.0
10	Air transport	0.0	0.0	239.0	0.0	0.0
11	Truck transport	0.0	0.0	381.6	0.0	0.0
12	Rail transport	0.0	0.0	159.5	0.0	0.0
13	Auto transport	0.0	0.0	1518.1	0.0	0.0
14	Total Consumption	10342.6	6396.6	4090.1	2208.4	2120.5

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TABLE C-12

Energy End Use, 2000, Scenario 6
(in trillion Btu's)

		Coal	Crude Oil and Gas	Refined Petroleum	Natural Gas	Electricity
1	Residential	1.4	0.0	227.4	519.6	201.1
2	Commercial	10.0	0.0	167.0	377.9	192.0
3	Industrial	1685.8	0.0	657.6	934.6	518.4
4	Electric Power	3262.8	0.0	447.9	6.5	126.9
5	Energy Conversion	95.3	5128.8	21.8	40.1	6.0
6	Agriculture	0.2	0.0	16.5	32.7	9.3
7	Mining	14.4	0.0	8.0	14.7	8.7
8	Construction	27.1	0.0	100.1	80.5	1.0
9	Water transport	0.0	0.0	99.0	0.0	0.0
10	Air transport	0.0	0.0	108.7	0.0	0.0
11	Truck transport	0.0	0.0	226.3	0.0	0.0
12	Rail transport	0.0	0.0	144.6	0.0	0.0
13	Auto transport	0.0	0.0	541.6	0.0	0.0
14	Total Consumption	5097.1	5128.8	2766.8	2006.4	1063.5

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